

Network Systems  
Science & Advanced  
Computing  
Biocomplexity Institute  
& Initiative  
University of Virginia

# Estimation of COVID-19 Impact in Virginia

March 2<sup>nd</sup>, 2022

(data current to February 26<sup>th</sup> – March 1<sup>st</sup>)

Biocomplexity Institute Technical report: TR 2022-016



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**BIOCOMPLEXITY** INSTITUTE

[biocomplexity.virginia.edu](https://biocomplexity.virginia.edu)

# About Us

- Biocomplexity Institute at the University of Virginia
  - Using big data and simulations to understand massively interactive systems and solve societal problems
- Over 20 years of crafting and analyzing infectious disease models
  - Pandemic response for Influenza, Ebola, Zika, and others



## Points of Contact

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# Overview

- **Goal:** Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project based on scenarios for next 4 months
  - Consider a range of possible mitigation effects in "what-if" scenarios
- **Outcomes:**
  - Ill, Confirmed, Hospitalized, ICU, Ventilated, Death
  - Geographic spread over time, case counts, healthcare burdens

# Key Takeaways

Projecting future cases precisely is impossible and unnecessary.

Even without perfect projections, we can confidently draw conclusions:

- **Case rates and hospitalizations continue to decline**
- VA 7-day mean daily case rate is sharply down to 19/100K from 30/100K
  - US is also lower now down to 22/100K (from 26/100K)
- Projections anticipate continued declines:
  - BA2 subvariant of Omicron continues to grow, but much more slowly than in European countries
  - Rapidity decline and final level of decline depends on degree of protection to Omicron garnered by previous Omicron infection

The situation continues to change. Models continue to be updated regularly.

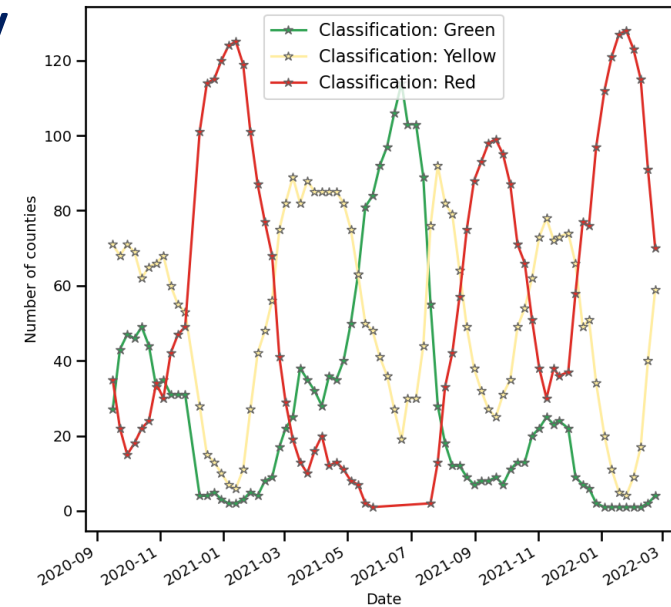


# Situation Assessment

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# Case Rates (per 100k) and Test Positivity

Data source: <https://data.cms.gov/covid-19/covid-19-nursing-home-data>

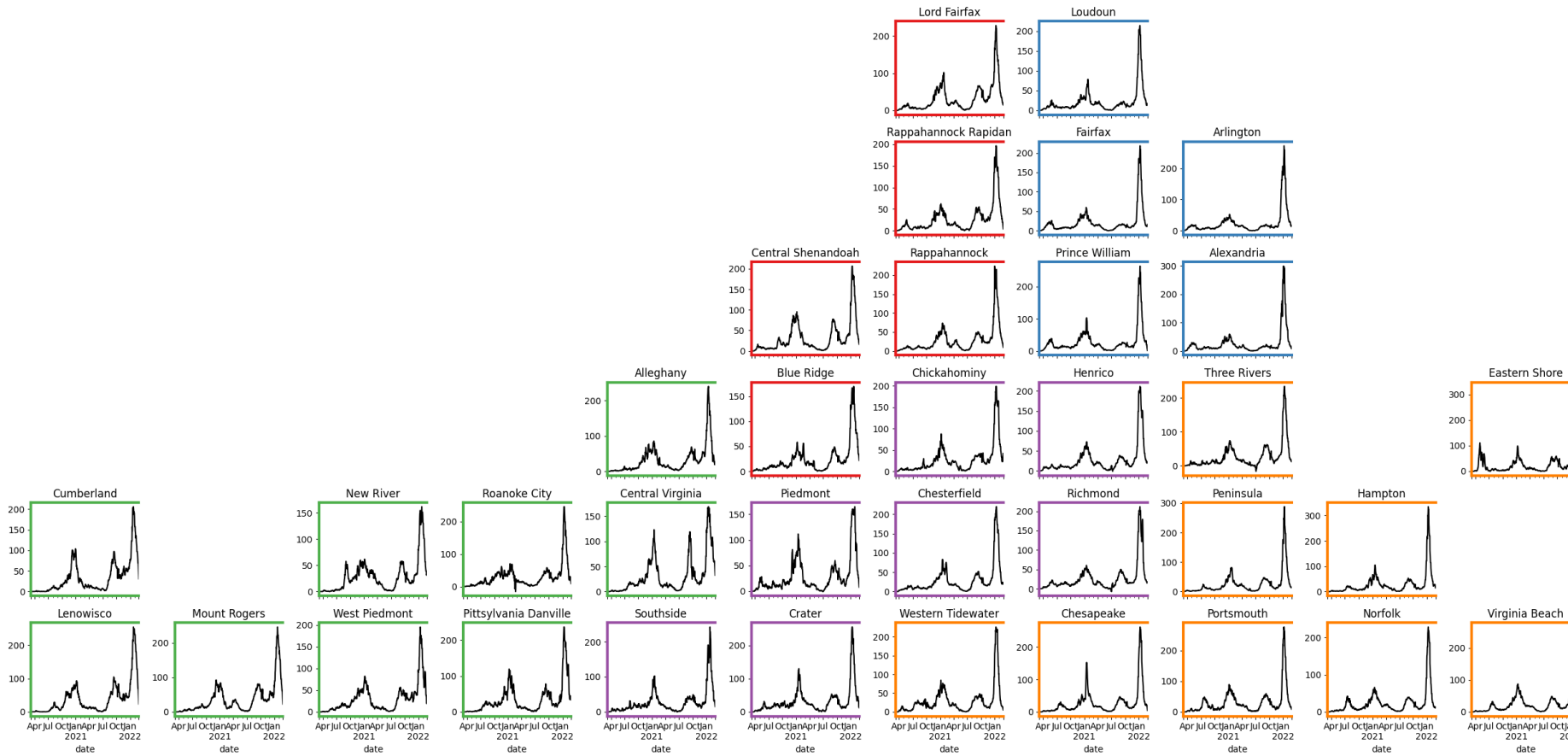


### County level RT-PCR test positivity

**Green:** <5.0% (or <20 tests in past 14 days)

**Yellow:** 5.0%-10.0% (or <500 tests and <2000 tests/100k and >10% positivity over 14 days)

**Red:** >10.0% (and not “Green” or “Yellow”)



# District Trajectories

**Goal:** Define epochs of a Health District's COVID-19 incidence to characterize the current trajectory

**Method:** Find recent peak and use hockey stick fit to find inflection point afterwards, then use this period's slope to define the trajectory

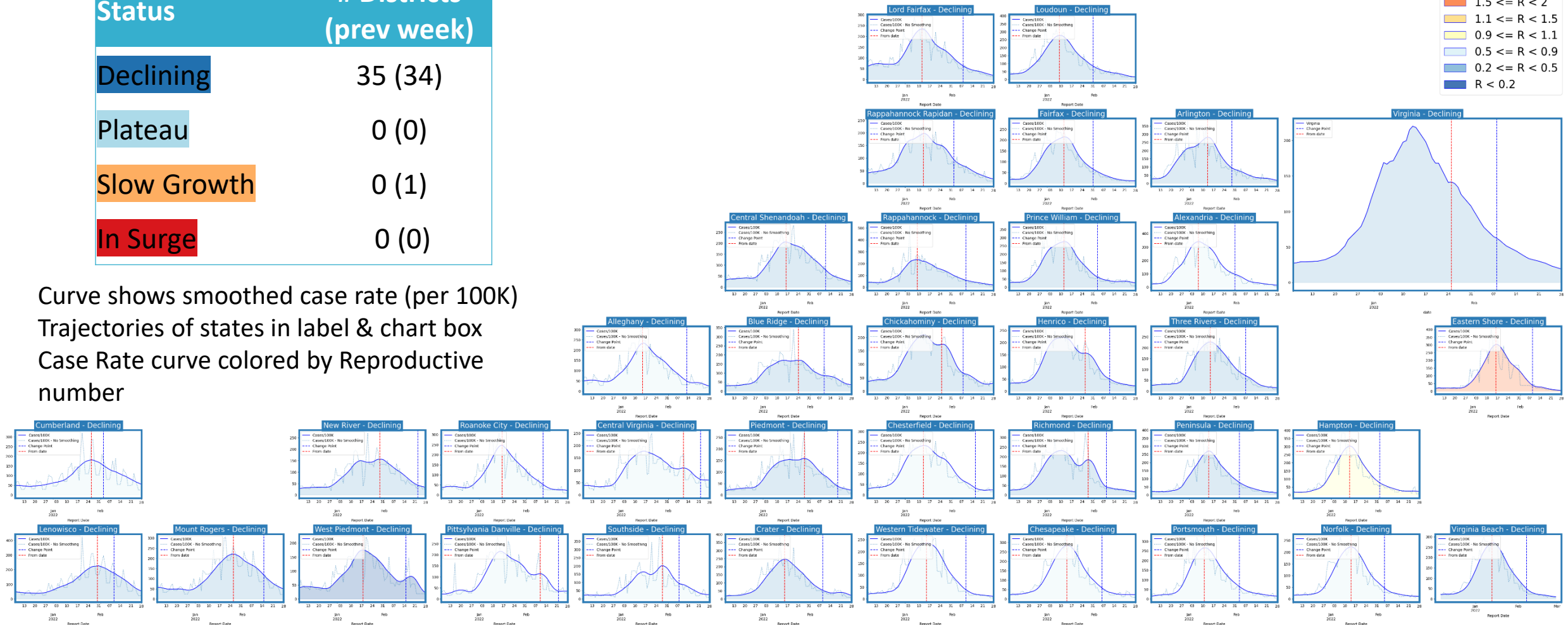


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
<b>Declining</b>	Sustained decreases following a recent peak	below -0.9	35 (34)
<b>Plateau</b>	Steady level with minimal trend up or down	above -0.9 and below 0.5	0 (0)
<b>Slow Growth</b>	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	0 (1)
<b>In Surge</b>	Currently experiencing sustained rapid and significant growth	2.5 or greater	0 (0)

# District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	35 (34)
Plateau	0 (0)
Slow Growth	0 (1)
In Surge	0 (0)

Curve shows smoothed case rate (per 100K)  
Trajectories of states in label & chart box  
Case Rate curve colored by Reproductive  
number



# CDC's new COVID-19 Community Levels

## What Prevention Steps Should You Take Based on Your COVID-19 Community Level?

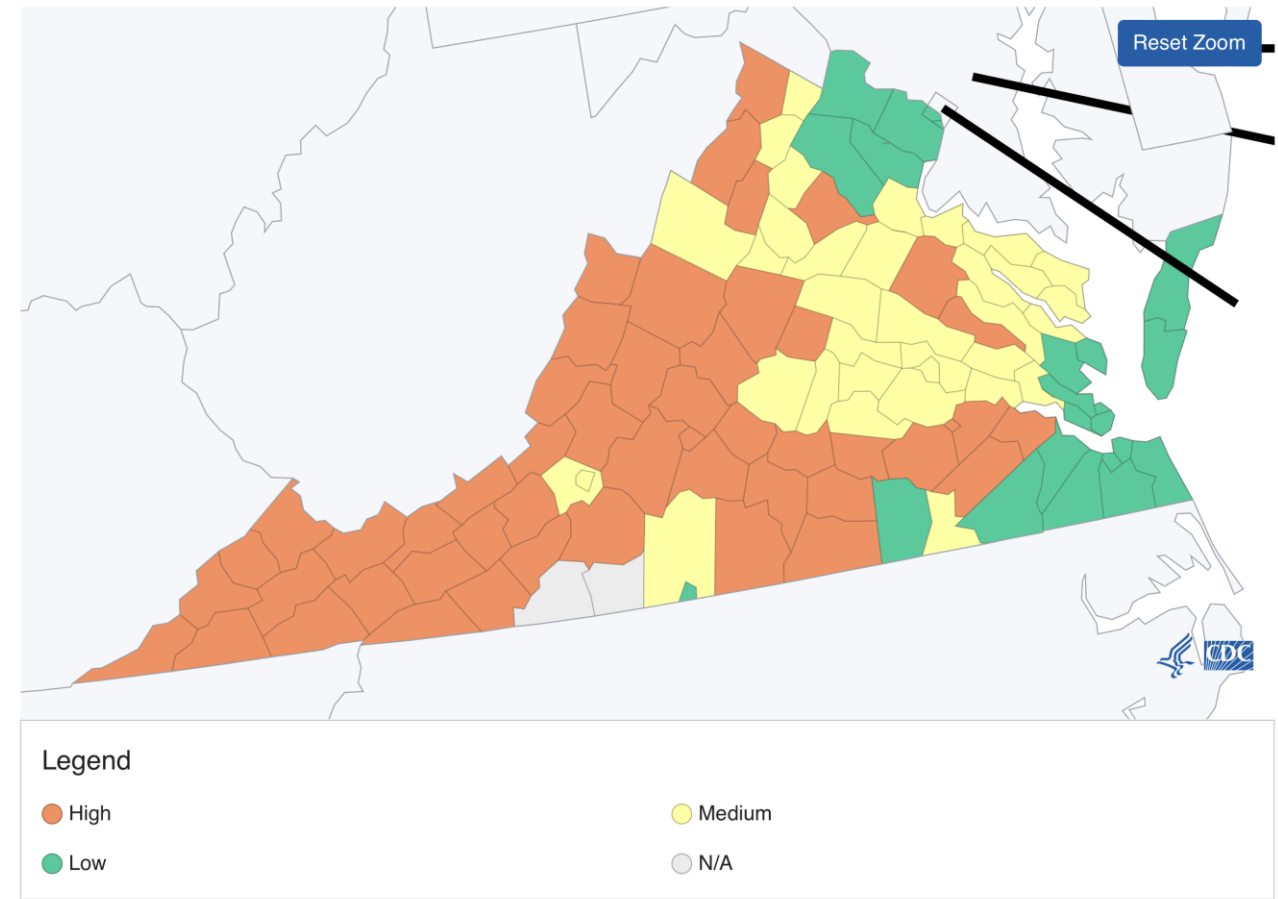
Low	Medium	High
<ul style="list-style-type: none"> <li>Stay <a href="#">up to date</a> with COVID-19 vaccines</li> <li><a href="#">Get tested</a> if you have symptoms</li> </ul>	<ul style="list-style-type: none"> <li>If you are <a href="#">at high risk for severe illness</a>, talk to your healthcare provider about whether you need to wear a mask and take other precautions</li> <li>Stay <a href="#">up to date</a> with COVID-19 vaccines</li> <li><a href="#">Get tested</a> if you have symptoms</li> </ul>	<ul style="list-style-type: none"> <li>Wear a <a href="#">mask</a> indoors in public</li> <li>Stay <a href="#">up to date</a> with COVID-19 vaccines</li> <li><a href="#">Get tested</a> if you have symptoms</li> <li>Additional precautions may be needed for people <a href="#">at high risk for severe illness</a></li> </ul>
People may choose to mask at any time. People with symptoms, a positive test, or exposure to someone with COVID-19 should wear a mask.		

COVID-19 Community Levels – Use the Highest Level that Applies to Your Community				
New COVID-19 Cases Per 100,000 people in the past 7 days	Indicators	Low	Medium	High
Fewer than 200	New COVID-19 admissions per 100,000 population (7-day total)	<10.0	10.0-19.9	≥20.0
	Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average)	<10.0%	10.0-14.9%	≥15.0%
200 or more	New COVID-19 admissions per 100,000 population (7-day total)	NA	<10.0	≥10.0
	Percent of staffed inpatient beds occupied by COVID-19 patients (7-day average)	NA	<10.0%	≥10.0%

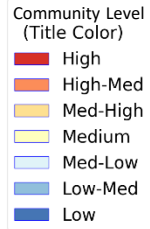
The COVID-19 community level is determined by the higher of the new admissions and inpatient beds metrics, based on the current level of new cases per 100,000 population in the past 7 days

## U.S. COVID-19 Community Levels by County

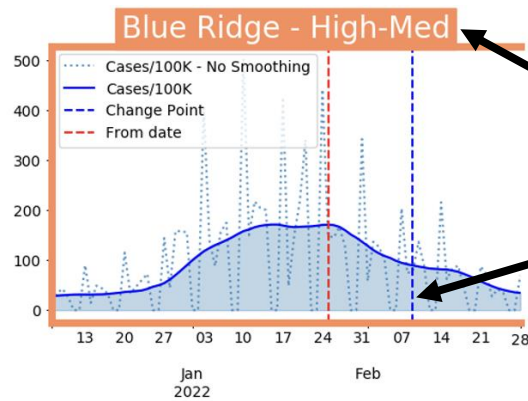
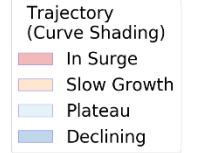
Data provided by CDC  
Updated: Feb. 24, 2022



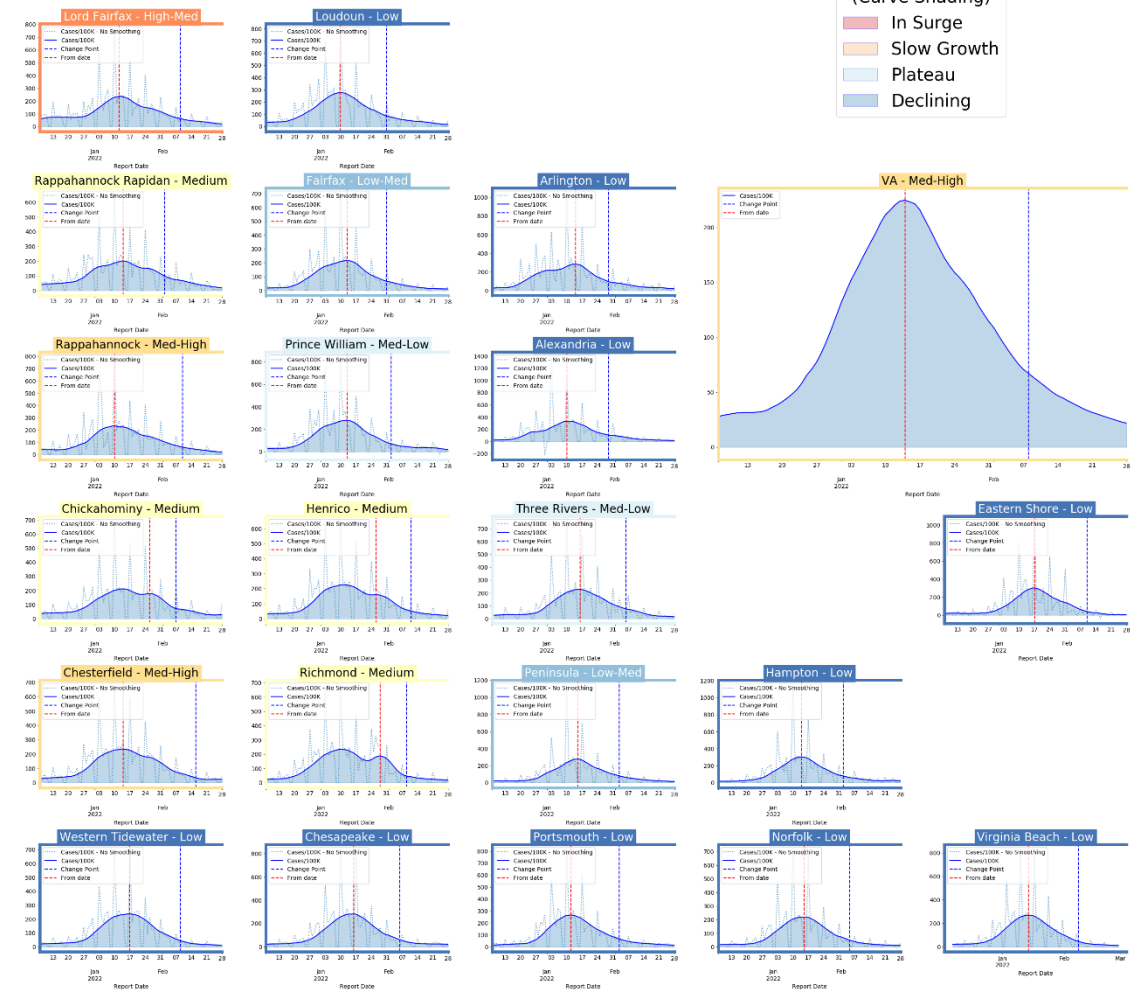
# District Trajectories with Community Levels



Curve shows smoothed case rate (per 100K)  
CDC's new [Community Level](#) aggregated to district level in label & chart box color  
Case Rate curve colored by Trajectory



District's Aggregate Community Level  
Aggregate level a simple mean of all levels for counties in district  
Case rate Trajectory





# Estimating Daily Reproductive Number – Redistributed gap

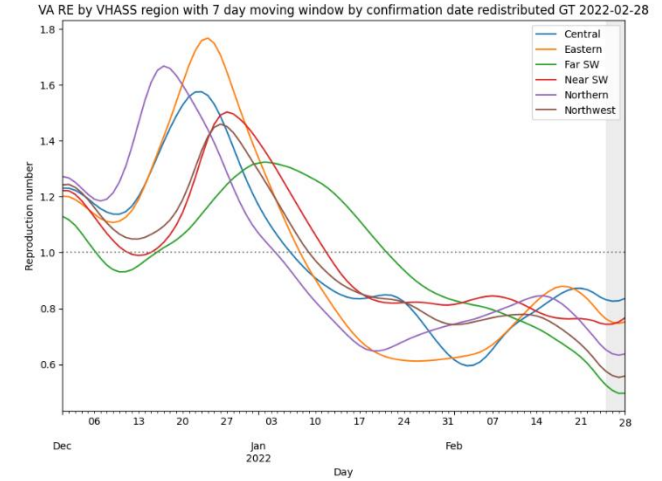
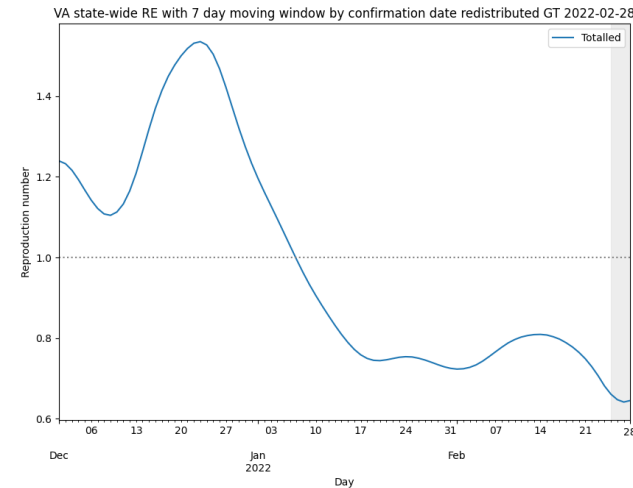
Feb 28<sup>th</sup> Estimates

Region	Date Confirmed $R_e$	Date Confirmed Diff Last Week
State-wide	0.645	-0.060
Central	0.836	0.126
Eastern	0.752	0.018
Far SW	0.497	-0.178
Near SW	0.767	0.074
Northern	0.638	-0.186
Northwest	0.558	-0.158

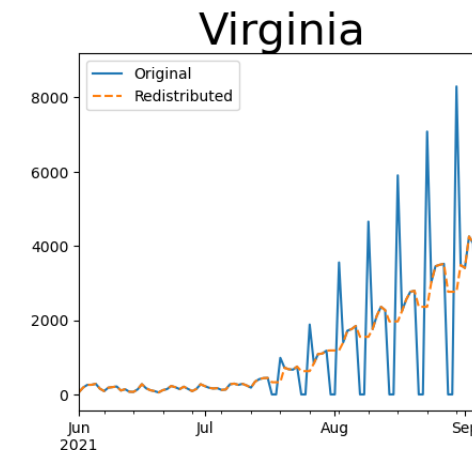
## Methodology

- Wallinga-Teunis method (EpiEstim<sup>1</sup>) for cases by confirmation date
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, <https://doi.org/10.1093/aje/kwt133>



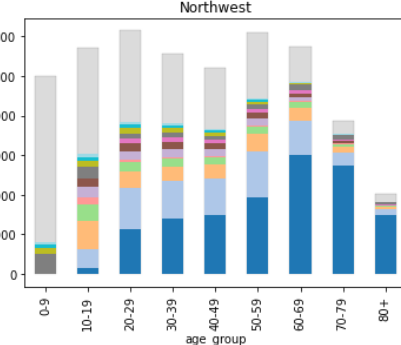
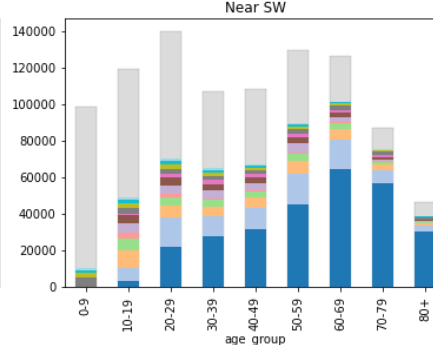
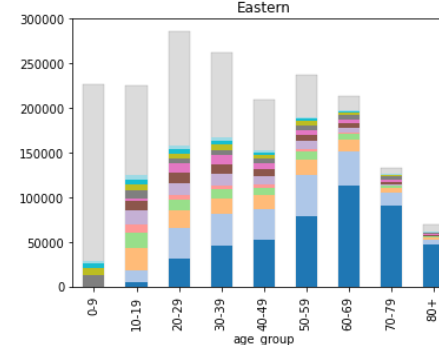
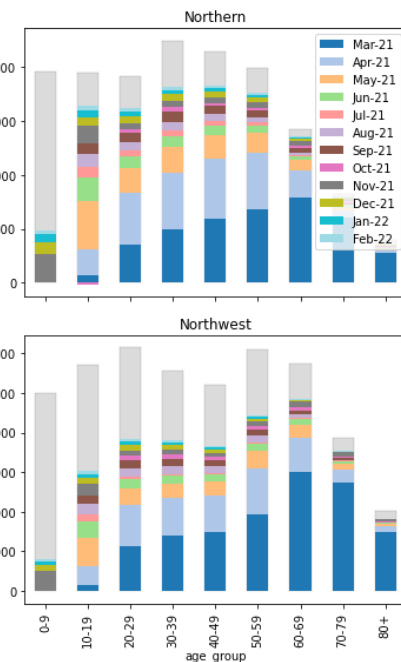
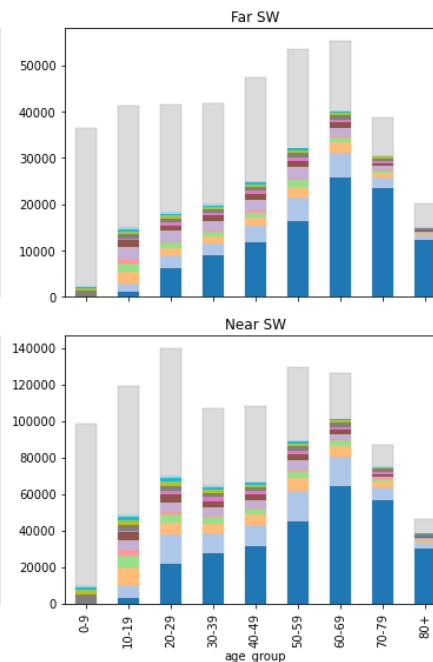
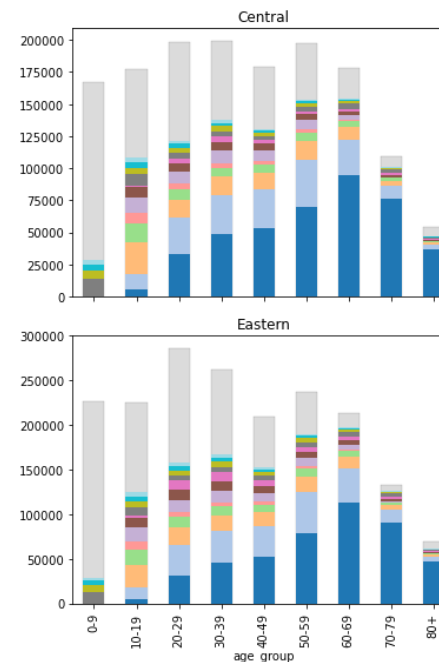
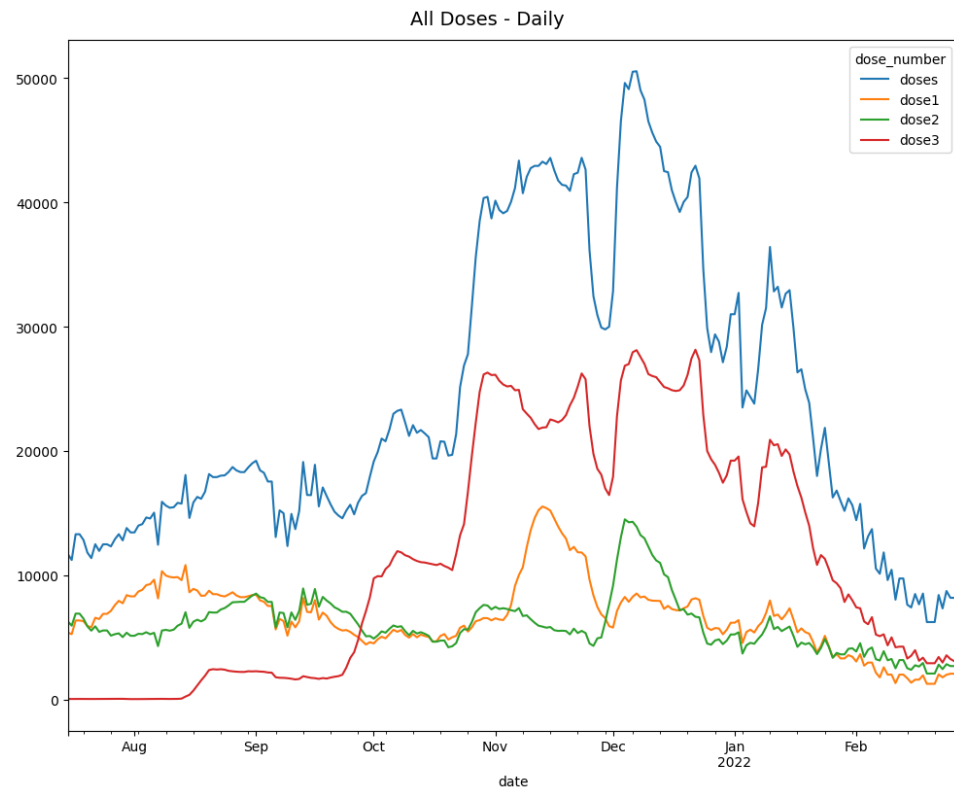
Skipping Weekend Reports & holidays biases estimates  
Redistributed “big” report day to fill in gaps, and then estimate R from “smoothed” time series



# Vaccination Administration in Virginia

## Vaccine Doses administered:

- Doses administered rates approach levels when vaccines were first available, but have leveled off
- Considerable reduction in vaccination rate experienced since mid-January
- Third dose administration outpaces 1<sup>st</sup> dose



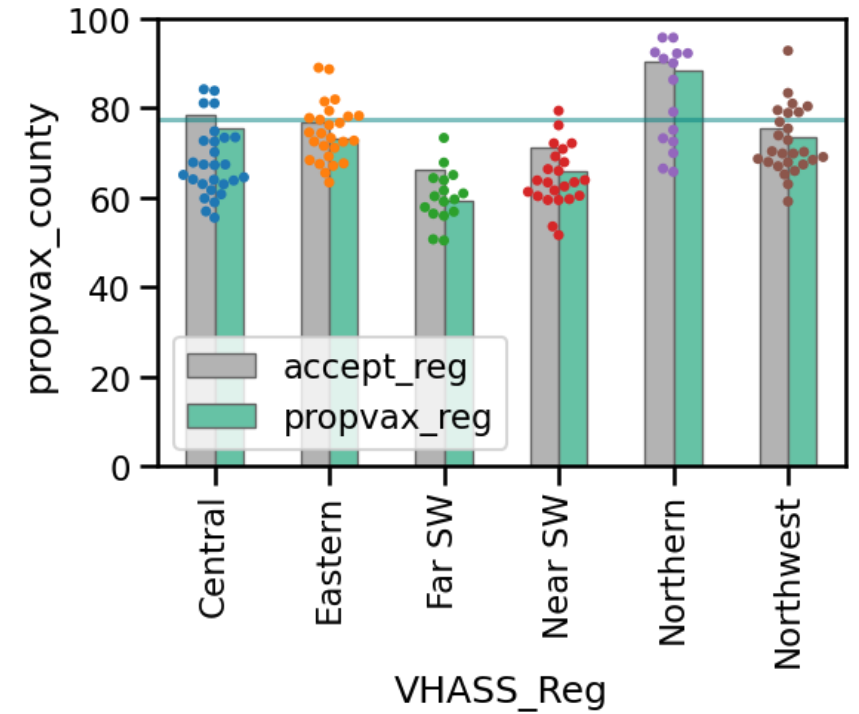


# Vaccination Acceptance by Region

## Corrections to surveys:

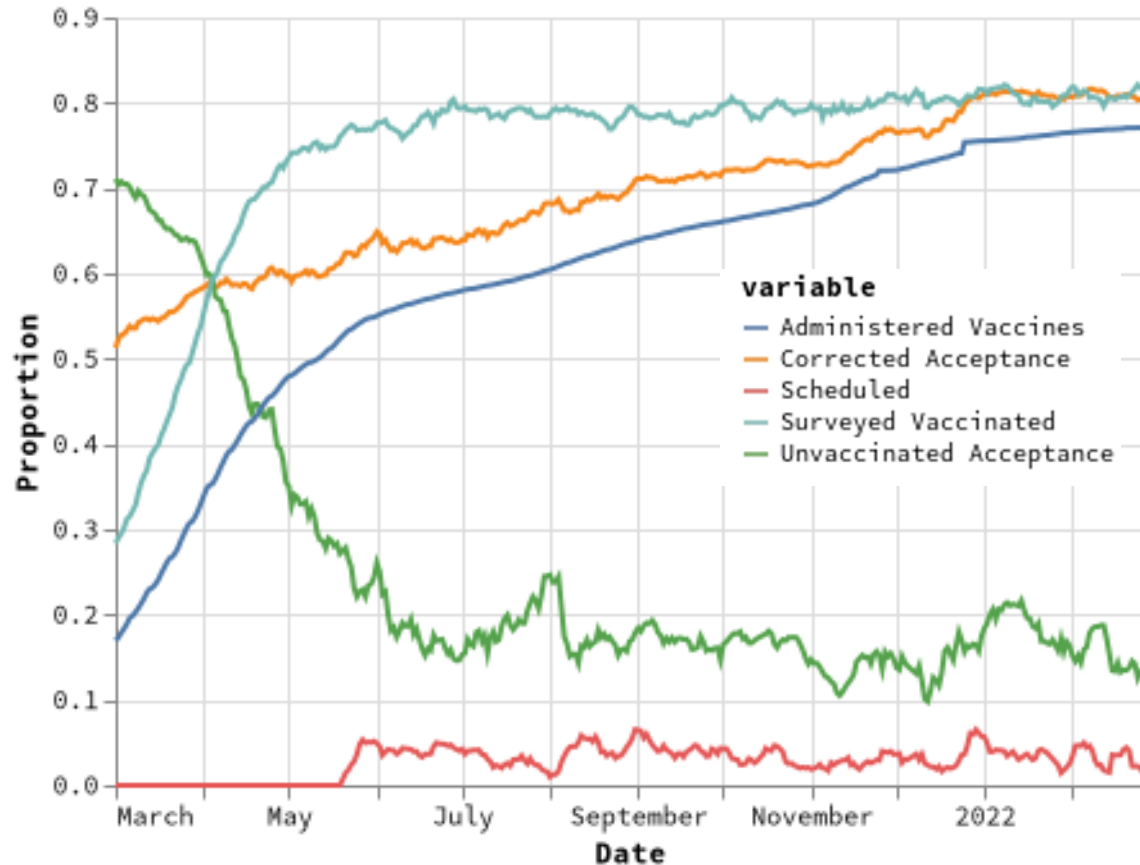
- Facebook administered survey is timely and broad, but biased by who accesses Facebook and answers the survey
- Correction approach:
  - Calculate an over-reporting fraction based on reported vaccinations compared to VDH administration data
  - Cross-validate coarse corrections against HPS survey at the state level and corrected in same manner

Region	COVIDcast accepting corrected	VDH proportion pop vaccinated
Central	78%	75%
Eastern	76%	73%
Far SW	62%	59%
Near SW	72%	66%
Northern	90%	88%
Northwest	75%	73%
<b>Virginia</b>	<b>80%</b>	<b>77%</b>



**Grey Bar:** Survey measured and corrected acceptance  
**Green Bar:** Proportion of eligible population administered a vaccine  
**Dots:** Proportion administered at least one dose for each county

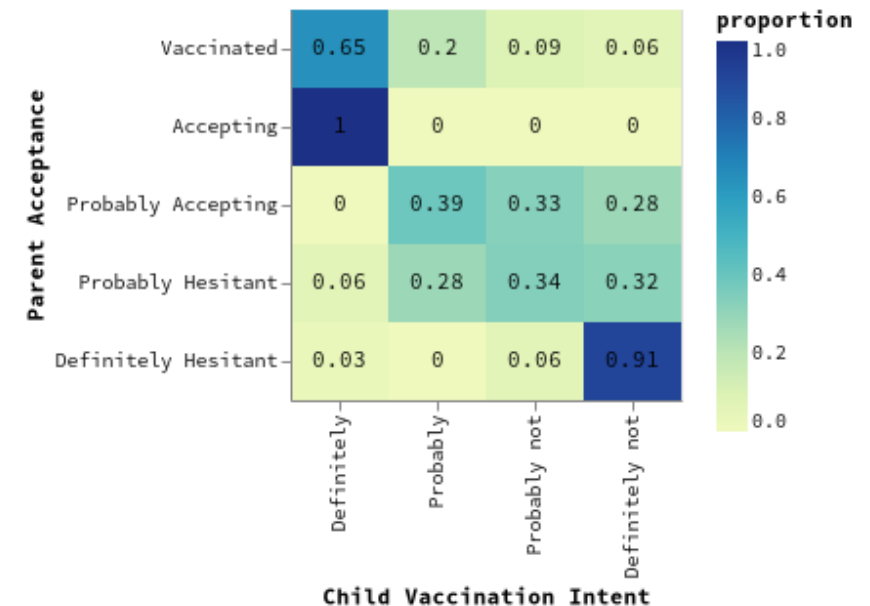
# Vaccine Acceptance Components over Time



## Vaccine Acceptance adjusted to include scheduled appointments

- Steady rise in acceptance over the past couple months
- Unvaccinated Acceptance shows ~12% of those who are unvaccinated are definitely or probably willing to be vaccinated

## Intent to Vaccinate Children Based on Parent's Acceptance Level



Data Source: <https://covidcast.cmu.edu>

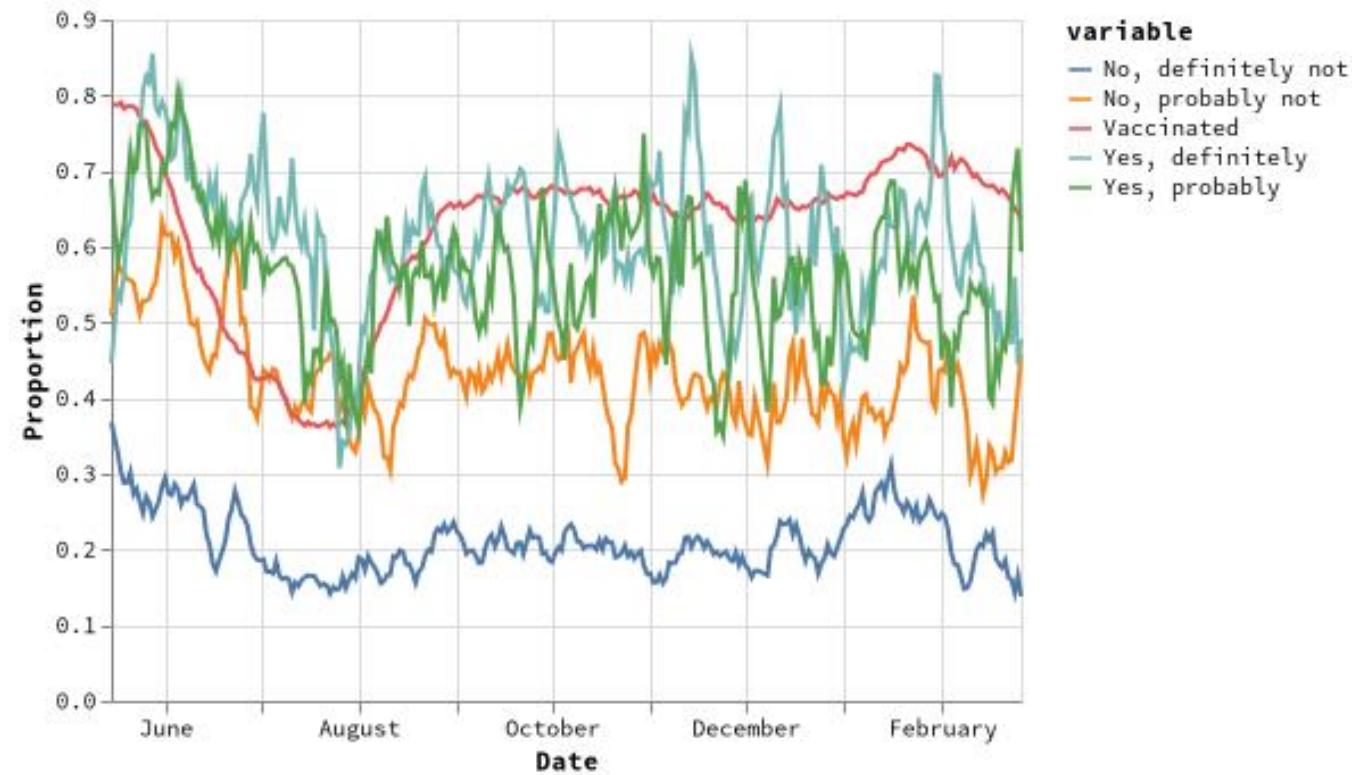
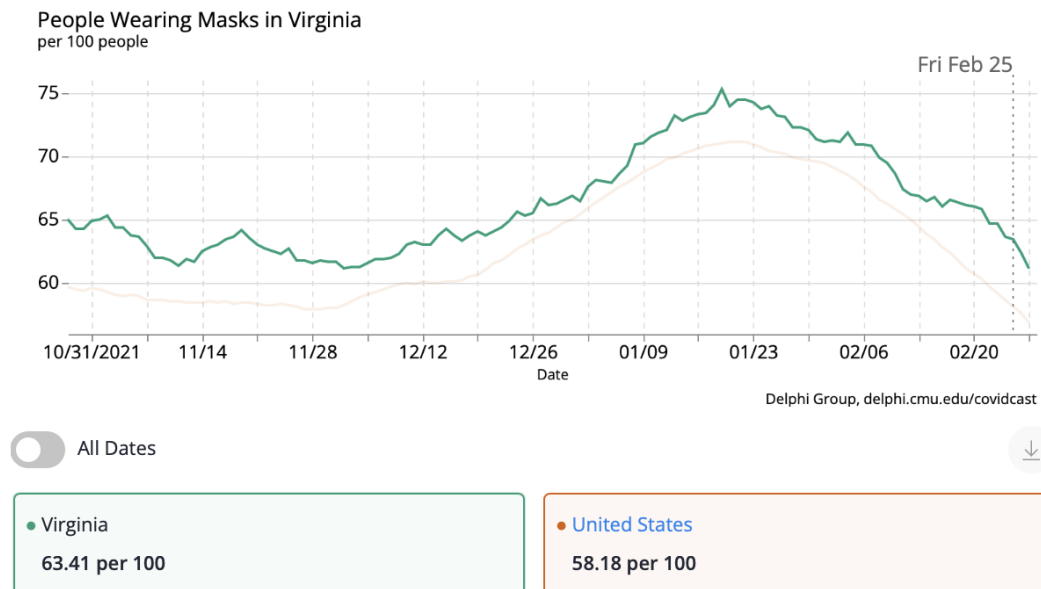
3-Mar-22

# Mask Usage Slows and Continues Decline

## Self-reported mask usage drops to lowest levels since late August

- US and VA experienced similar decreases
- Mask wearing remains lower amongst unvaccinated especially among least willing to be vaccinated

### PEOPLE WEARING MASKS CHART

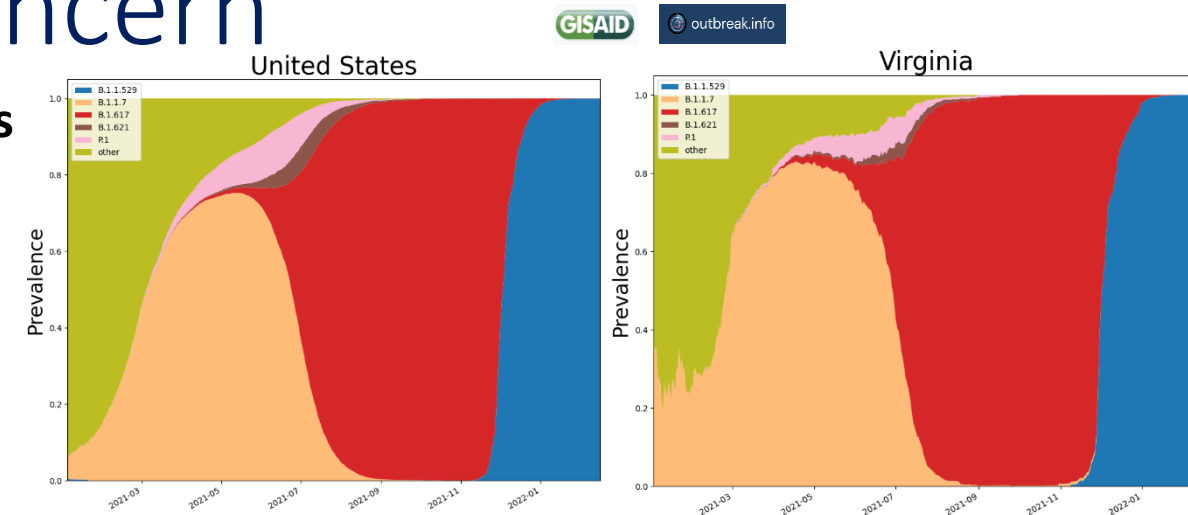


# SARS-CoV2 Variants of Concern

Emerging new variants will alter the future trajectories of pandemic and have implications for future control

- Emerging variants can:
  - Increase transmissibility
  - Increase severity (more hospitalizations and/or deaths)
  - Limit immunity provided by prior infection and vaccinations
- Genomic surveillance remains very limited
  - Challenges ability to estimate impact in US to date and estimation of arrival and potential impact in future

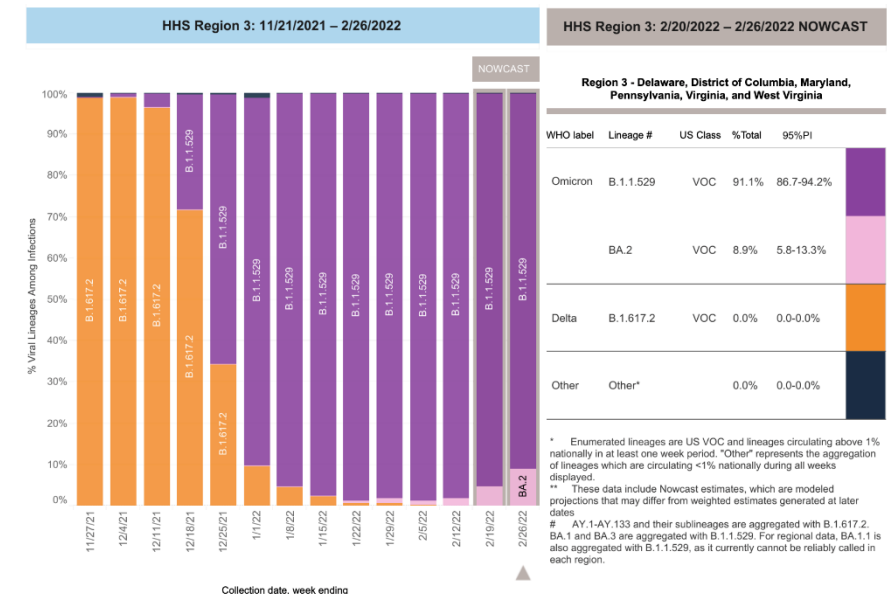
WHO label	Pango lineage*	GISAID clade	Nextstrain clade	Additional amino acid changes monitored*	Earliest documented samples	Date of designation
Alpha	B.1.1.7	GRY	20I (V1)	+S:484K +S:452R	United Kingdom, Sep-2020	18-Dec-2020
Beta	B.1.351	GH/501Y.V2	20H (V2)	+S:L18F	South Africa, May-2020	18-Dec-2020
Gamma	P.1	GR/501Y.V3	20J (V3)	+S:681H	Brazil, Nov-2020	11-Jan-2021
Delta	B.1.617.2	GI/478K.V1	21A, 21I, 21J	+S:417N +S:484K	India, Oct-2020	VOI: 4-Apr-2021 VOC: 11-May-2021
Omicron*	B.1.1.529	GRA	21K, 21L	+R346K	Multiple countries, Nov-2021	VUM: 24-Nov-2021 VOC: 26-Nov-2021



**Omicron Prevalence**  
CDC now tracking subvariant BA.2

CDC nowcast for week ending Feb 26<sup>th</sup> shows 8.6% BA.2 in Region 3, up from 4.7% previous week

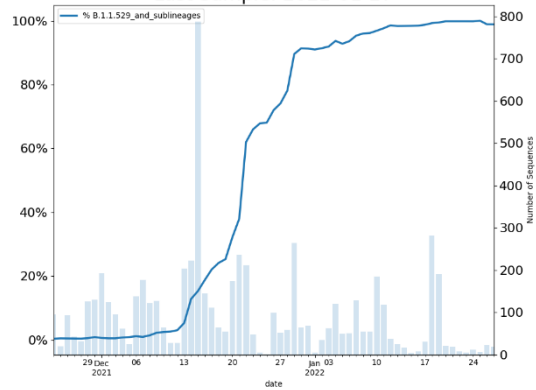
Now all other VOCs are at 0.00%



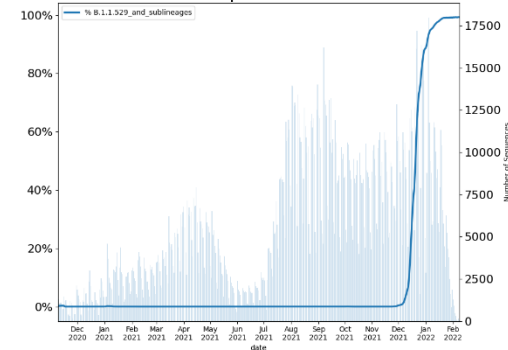
# SARS-CoV2 Variants of Concern

## Omicron o - Lineage B.1.1.529

Virginia - 98.9% (['B.1.1.529', 'BA.1', 'BA.1.1', 'BA.2'])  
Last Sample: 2022-01-27

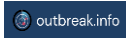
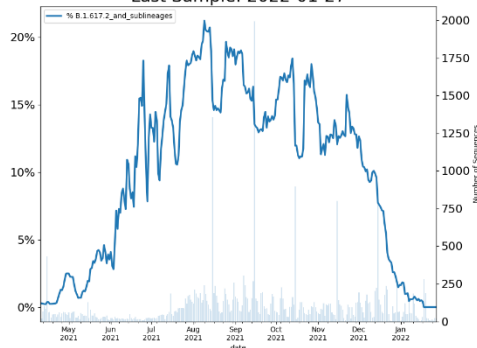


United States - 99.3% (['B.1.1.529', 'BA.1', 'BA.1.1', 'BA.2'])  
Last Sample: 2022-02-08



## Delta $\delta$ - Lineage B.1.617.2

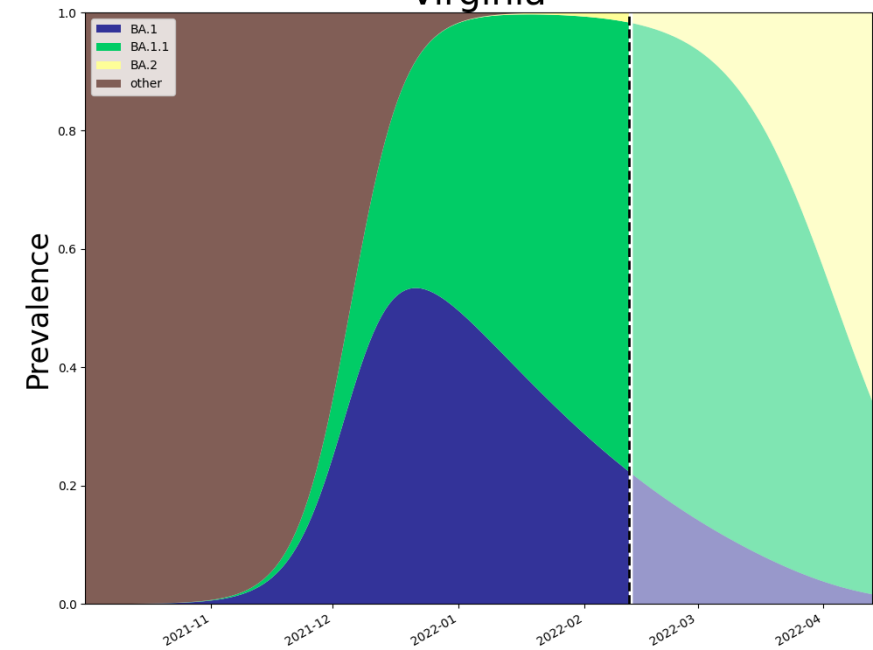
7.2', 'AY.1', 'AY.10', 'AY.11', 'AY.12', 'AY.2', 'AY.3', 'AY.3.1', 'AY.4', 'A  
Last Sample: 2022-01-27



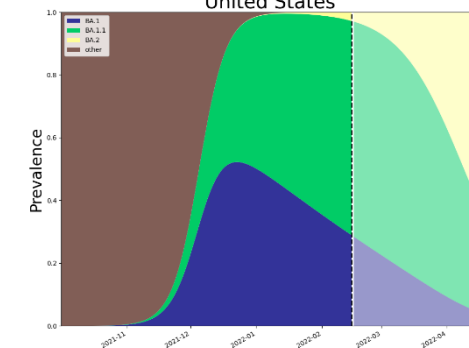
3-Mar-22

## VoC Polynomial Fit Projections

## Virginia



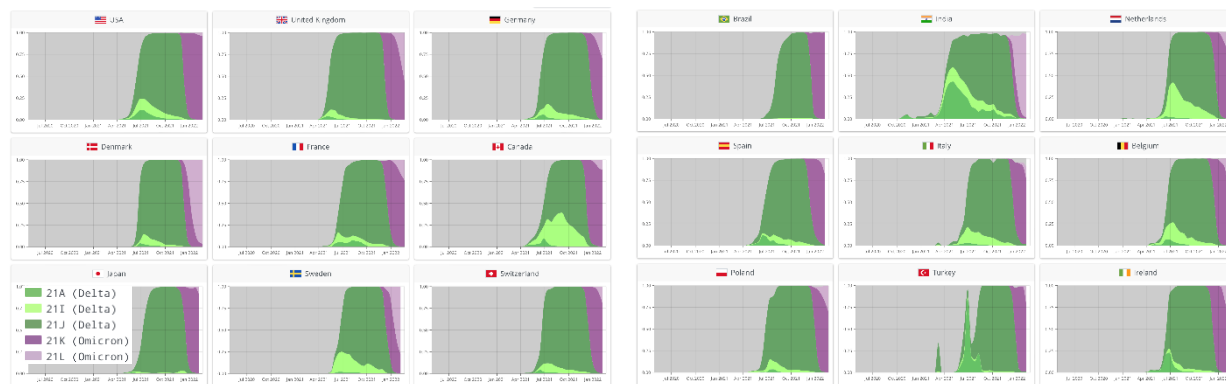
United States



# SARS-CoV2 BA.2 subvariant Tracking

## BA.2 subvariant growing rapidly in some European countries

- Both Delta and the Omicron BA.2 subvariant don't have the SGTF signal with PCR tests, so the reduction caused by Omicron BA.1 SGTF can be an imperfect signal for increased BA.2
- Subvariant BA.2 in all HHS regions of USA, Region 3 (includes VA) has highest estimated prevalence
- BA.2 is now majority subvariant in most northern European countries and India and some neighbors

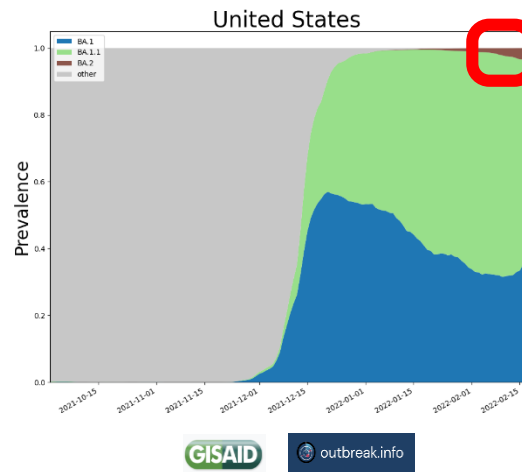
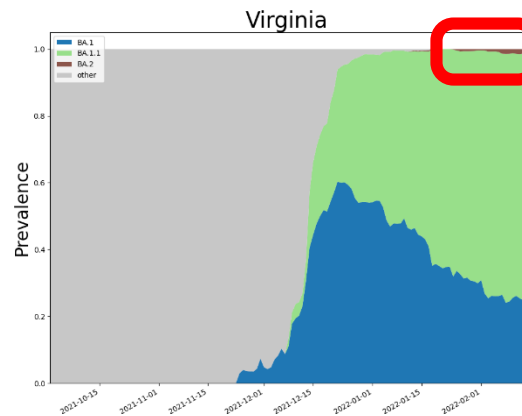


[CoVariants.org](https://covid19.co-variants.org/)

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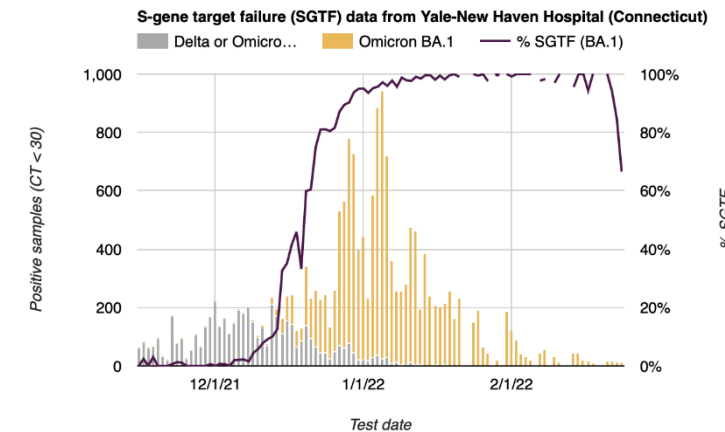
## Whole Genomes in public repositories



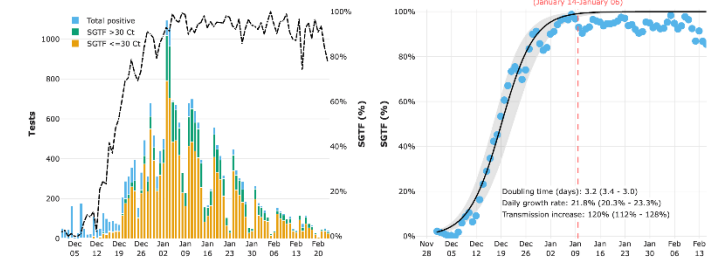
GISAID outbreak.info

## SGTF proxy in US

### Yale- New Haven



### San Diego

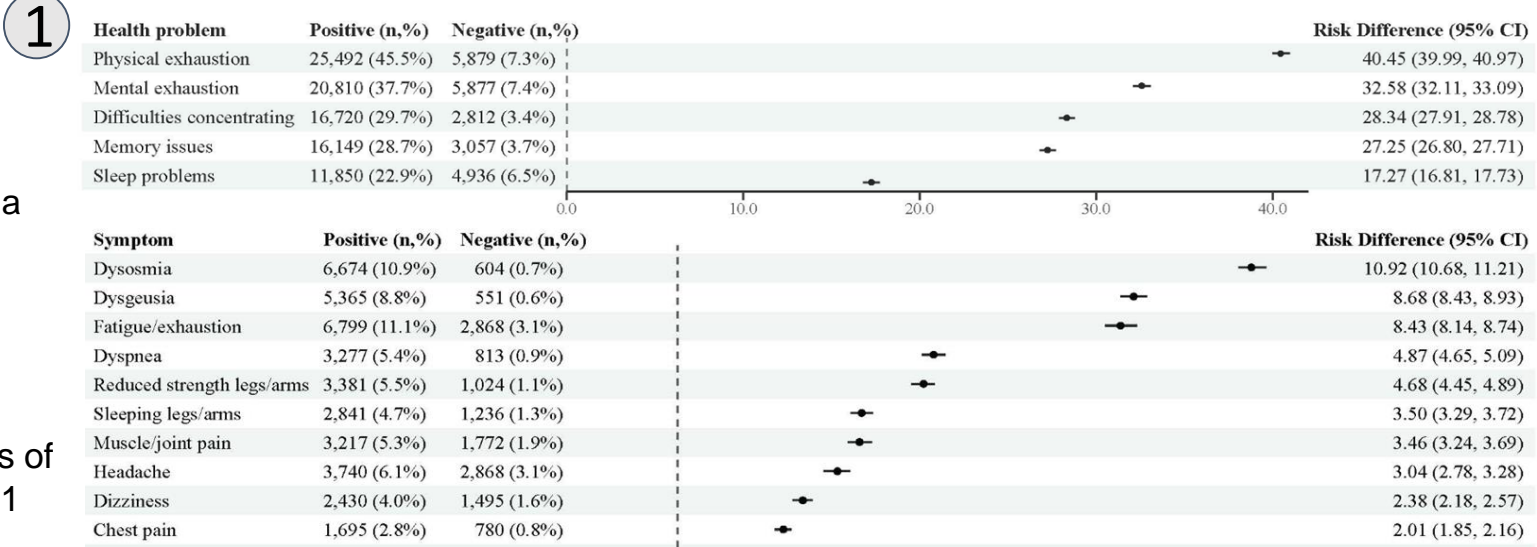


Some drops in SGTF in CT and CA



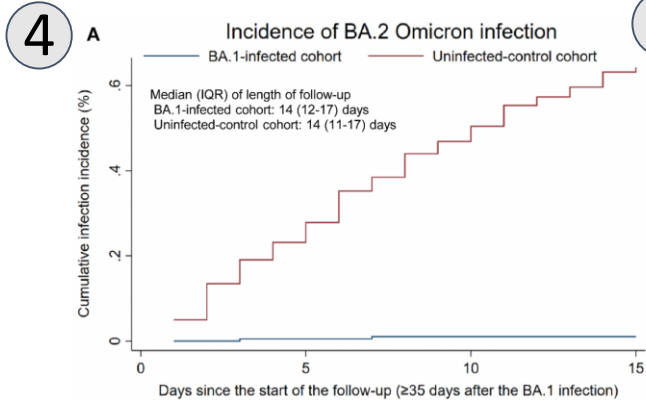
# Pandemic Pubs

- 1. Denmark at the population-level, where the majority of test-positives (96.0%) were not hospitalized during acute infection, a considerable proportion experience post-acute symptoms and sequelae 6-12 months after infection.
- 2. Tokyo experiments indicate BA.2 is more pathogenic than BA.1 in animal model and BA.2 is more replicative in human nasal epithelial cells.
- 3. During Omicron dominance the effectiveness against cases of BNT162b2 declined rapidly for children, particularly those 5-11 years. However, vaccination of children 5-11 years was protective against severe disease and is recommended.
- 4. Qatar study shows infection with one Omicron sub-lineage induces "strong, but not full protection" against reinfection from another.



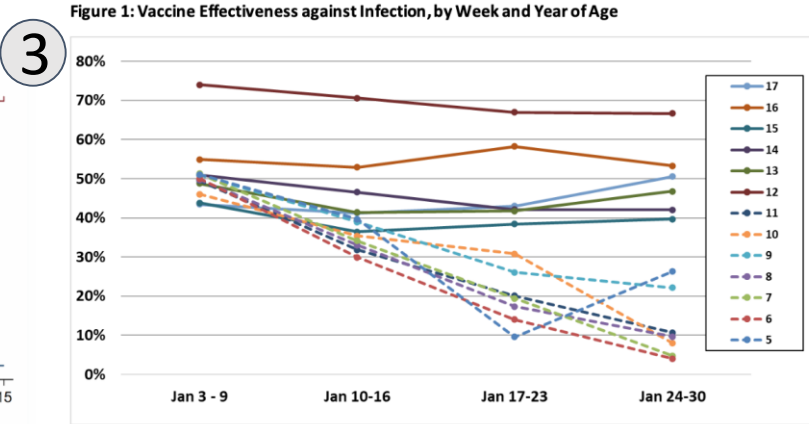
Denmark nationwide cross-sectional study including 152,880 individuals aged 15-years or older. Data were collected 6, 9 or 12 months after the test using web-based questionnaires. More than half (53.1%) of test-positives reported at least one of the following conditions: concentration difficulties, memory issues, sleep problems, mental or physical exhaustion, compared to 11.5% of test-negatives.

<https://www.medrxiv.org/content/10.1101/2022.02.27.22271328v1.full.pdf>



Qatar: Two national matched, retrospective cohort studies were conducted to estimate effectiveness of BA.1 infection against reinfection with BA.2 (N=20,197; BA.1-against-BA.2 study), and effectiveness of BA.2 infection against reinfection with BA.1 (N=100,925; BA.2-against-BA.1 study). **BA.1 is 94.9% effective against BA.2; BA.2 is 85.6% effective against BA.1**

<https://www.medrxiv.org/content/10.1101/2022.02.24.22271440v1>



Incidence rate ratios, comparing cases during January 3 - January 30, 2022 for unvaccinated versus children newly fully-vaccinated December 13, 2021-January 2, 2022, by time Since Full Vaccination. Possible relationship between CDC recommended dosing in #2 and demonstrated waning in younger age groups

<https://www.medrxiv.org/content/10.1101/2022.02.25.22271454v1>

2

TABLE 2. COVID-19 vaccination schedule for the primary series in the general population\*

Primary series vaccine manufacturer	Age group	Number of doses in primary series	Number of booster doses	Interval between 1st and 2nd dose	Interval between primary series and booster dose
Pfizer-BioNTech	5-11 years	2	NA	3 weeks	NA
Pfizer-BioNTech	≥12 years	2	1	3-8 weeks†	≥5 months
Moderna	≥18 years	2	1	4-8 weeks†	≥5 months
Janssen	≥18 years	1	1	NA	≥2 months

\*For the vaccination schedule for people who are moderately or severely immunocompromised, see [Table 3](#)

†An **8-week** interval may be optimal for some people ages 12 years and older, especially for males ages 12 to 39 years. A **shorter interval** (3 weeks for Pfizer-BioNTech; 4 weeks for Moderna) between the first and second doses remains the recommended interval for: people who are moderately to severely immunocompromised; adults ages 65 years and older; and others who need rapid protection due to increased concern about community transmission or risk of severe disease.

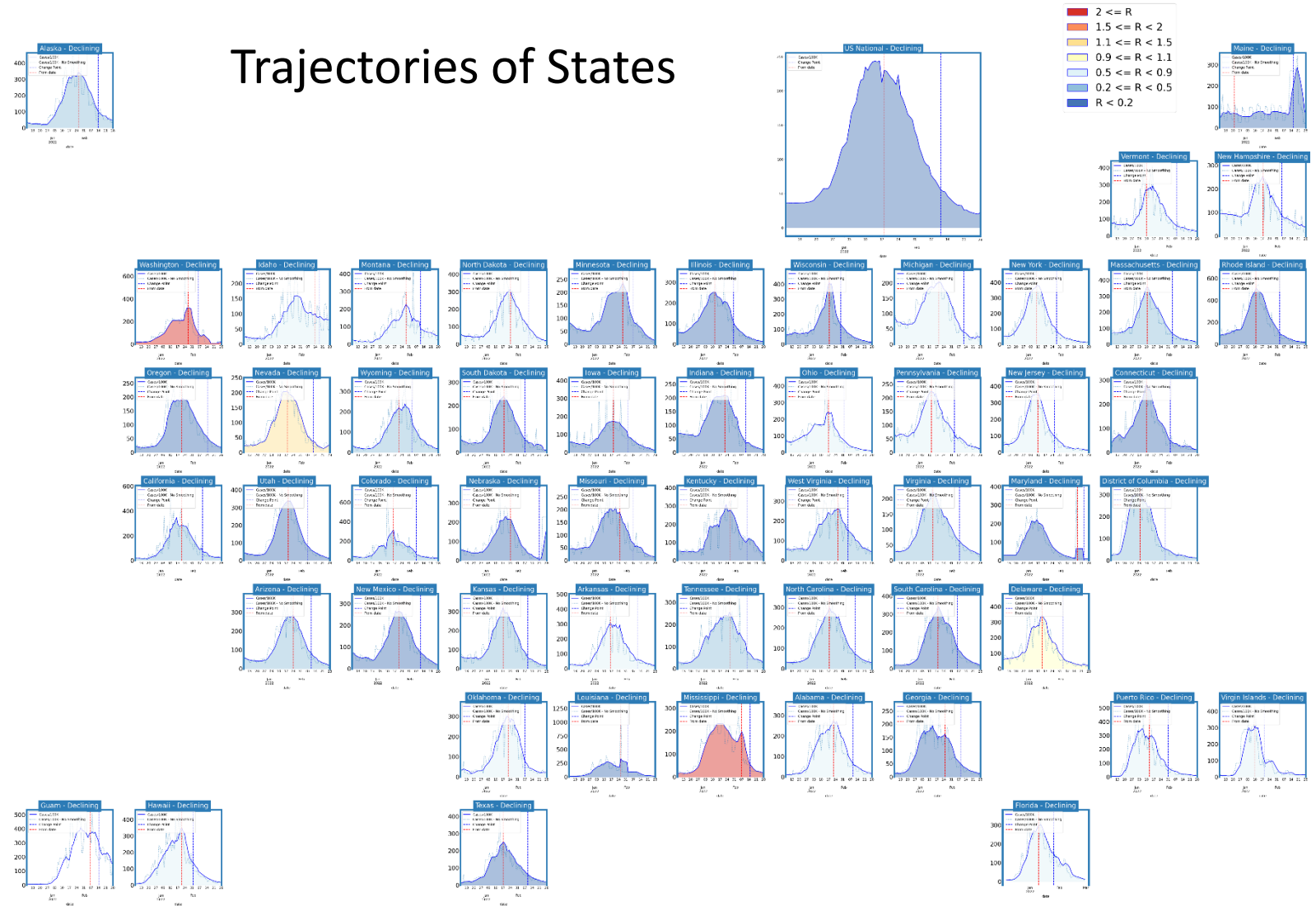
CDC recently updated guidance on vaccinations to acknowledge an 8-week interval between doses may be optimal for those 12 years and older,

<https://www.cdc.gov/vaccines/covid-19/clinical-considerations/covid-19-vaccines-us.html#primary-series>

# United States Case Rates

- All states have shifted to a declining trajectory

## Trajectories of States



### Status

### # States

Declining

54 (54)

Plateau

0 (0)

Slow Growth

0 (0)

In Surge

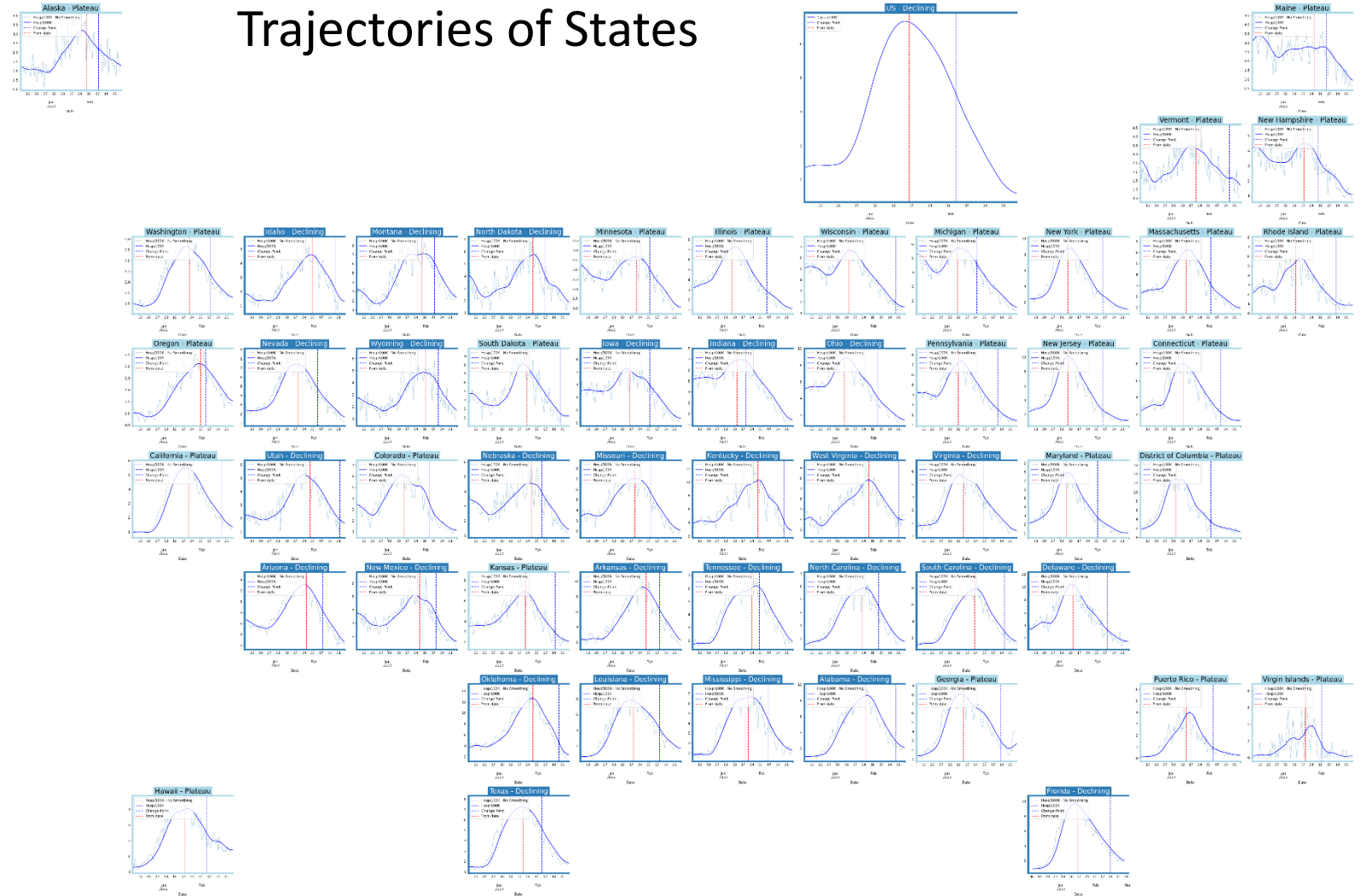
0 (0)



# United States Hospitalizations

- Hospital admissions are lagging case rates, but are mixed across the states
- Many states in growth trajectories show signs of slowing

## Trajectories of States



### Status

### # States

Declining

27 (32)

Plateau

26 (21)

Slow Growth

0 (0)

In Surge

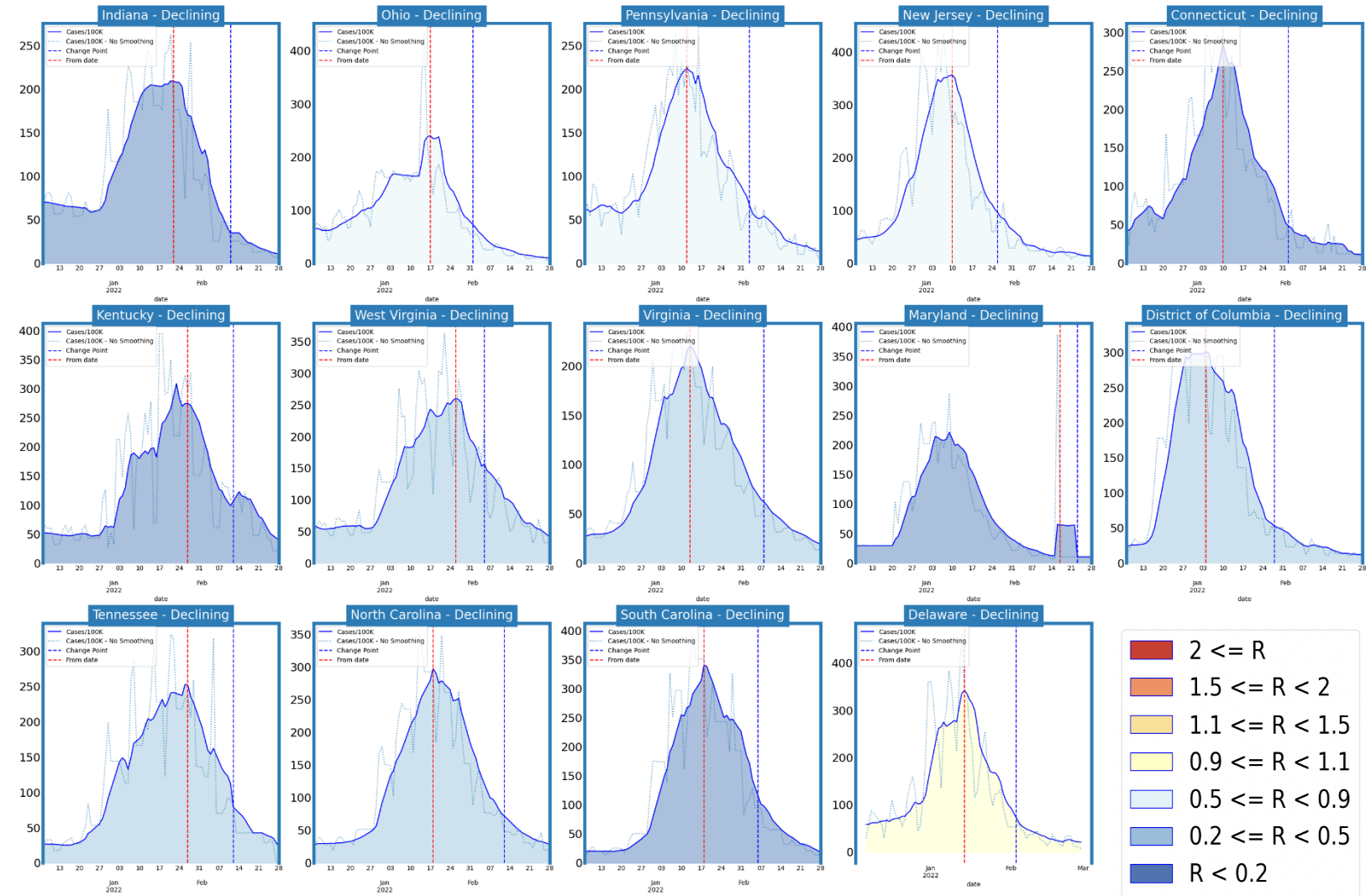
0 (0)



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# Virginia and Her Neighbors

- All have dramatically dropped from peaks
- Rates have moderated
- Nearly all states below 25/100K, even the highest have now dropped below 50/100K
- Many states to north and east have started to show plateauing of rates in recent weeks

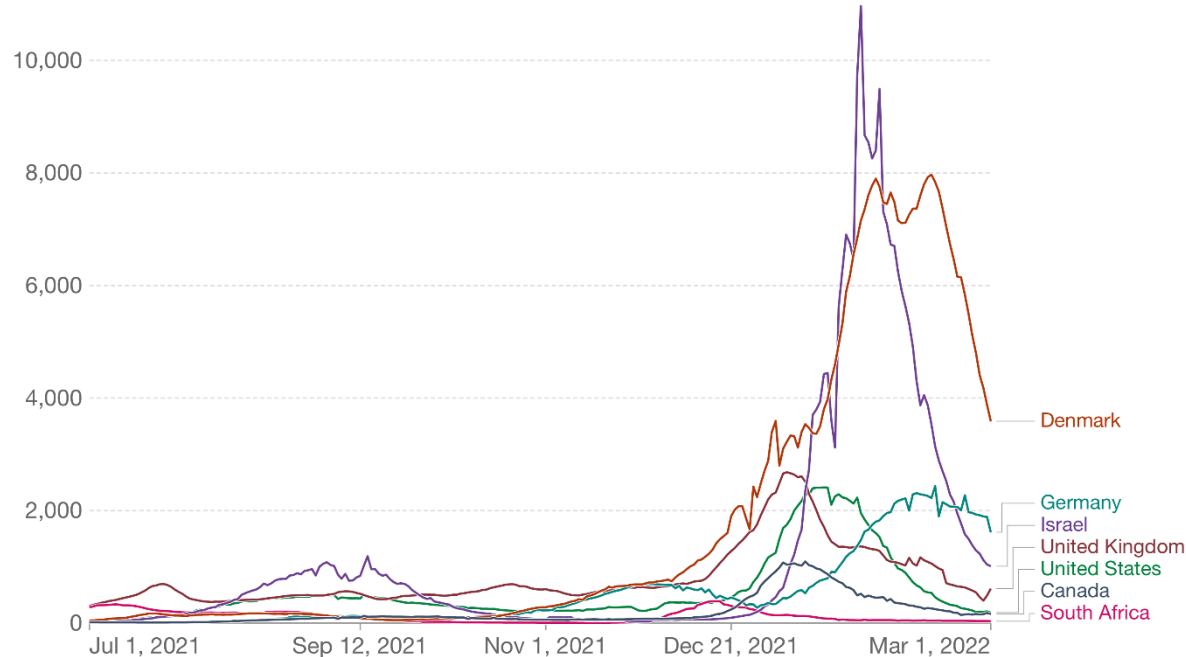


# Other Countries

- UK continues to see case rates flattening out, and case rates are very high but flat in Denmark
- US, Israel, Sweden have continued declines, start to slow
- US per capita hospitalization rates have declined dramatically

## Daily new confirmed COVID-19 cases per million people

7-day rolling average. Due to limited testing, the number of confirmed cases is lower than the true number of infections.

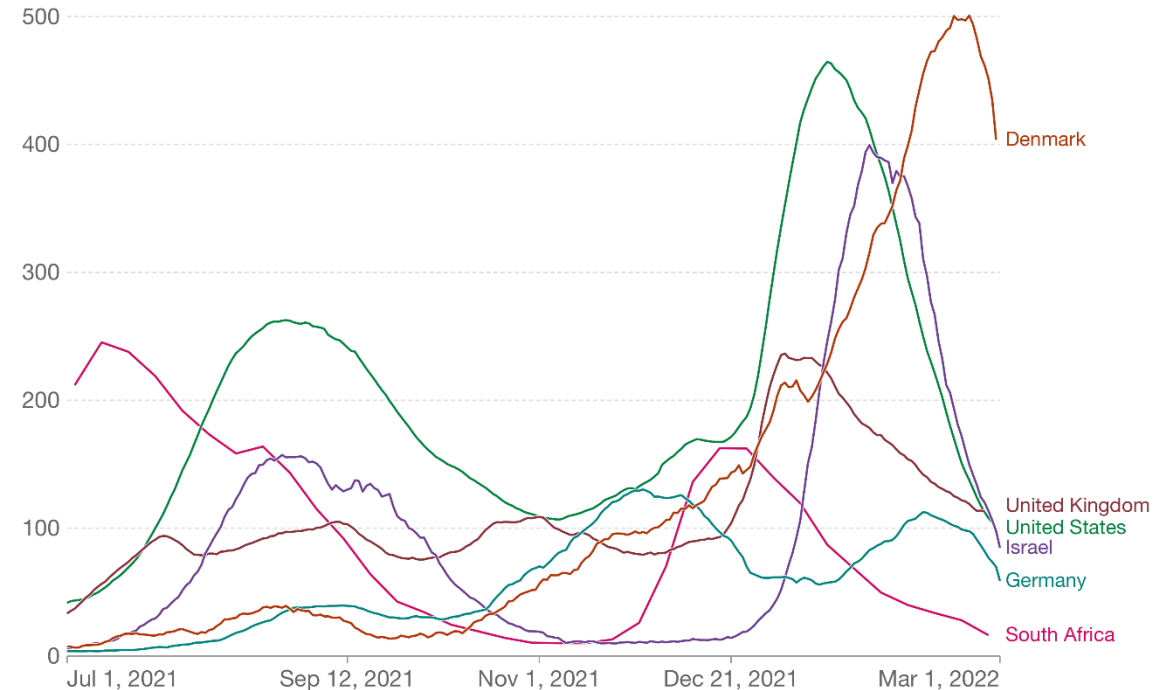


Source: Johns Hopkins University CSSE COVID-19 Data

Our World  
in Data

## Weekly new hospital admissions for COVID-19 per million people

Weekly admissions refer to the cumulative number of new admissions over the previous week.



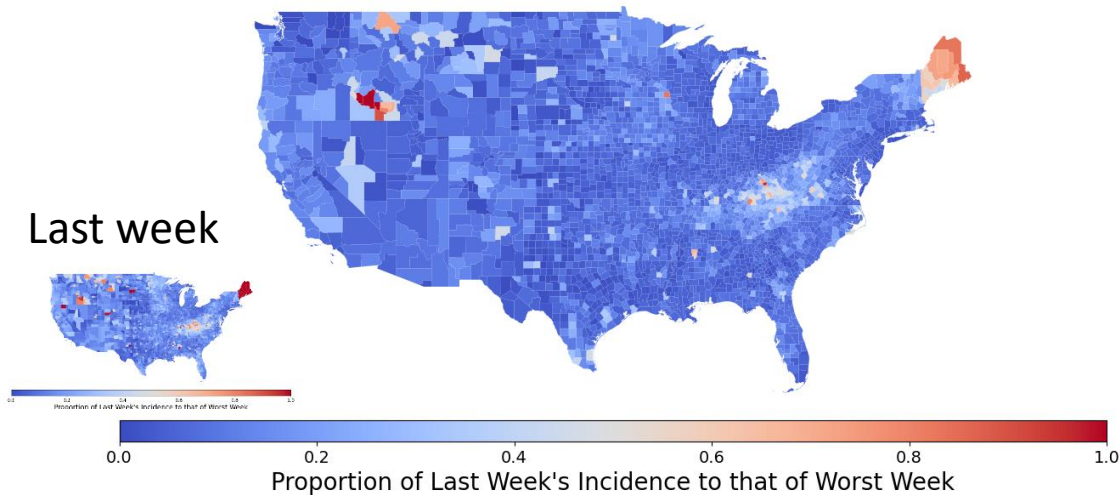
Source: Official data collated by Our World in Data

Our World  
in Data

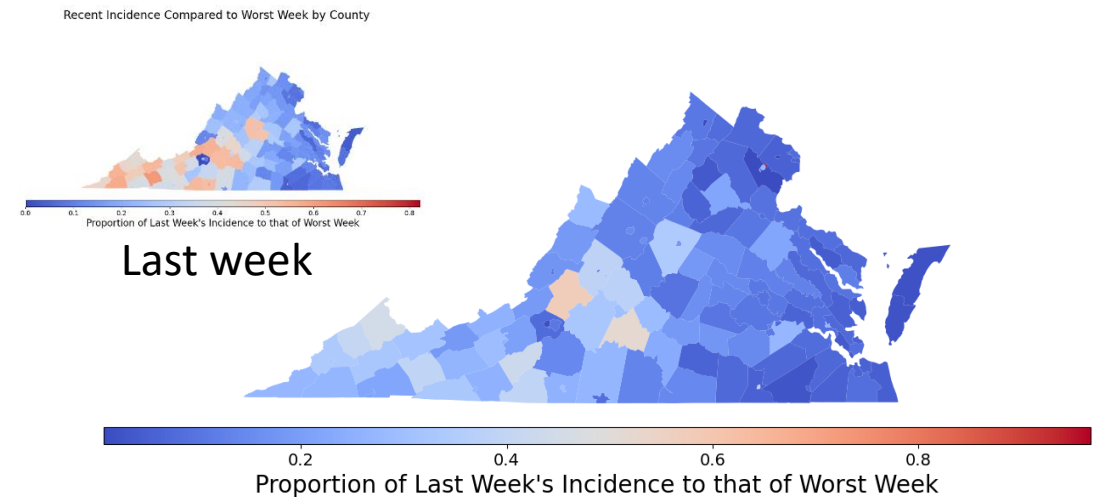
# County-level comparison to previous highest peak

- Most counties in VA have had the highest case rate of the pandemic in the last week
- Nationally the number of counties at their highest rate has expanded considerably

Recent Incidence Compared to Worst Week by County



Recent Incidence Compared to Worst Week by County





# Zip code level weekly Case Rate (per 100K)

## Case Rates in the last week by zip code

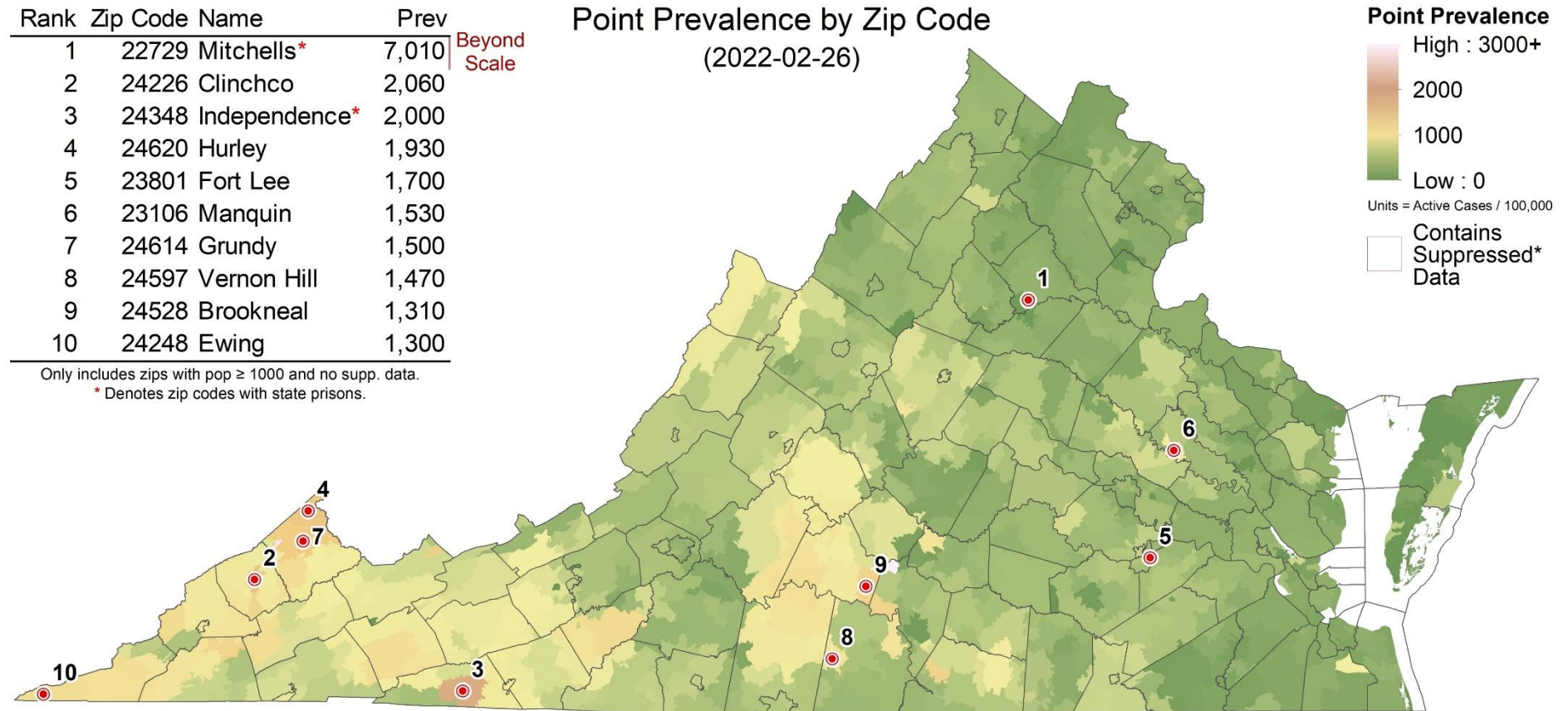
- Clusters of high prevalence in Southwest
- Some counts are low and suppressed to protect anonymity, those are shown in white

Rank	Zip Code	Name	Prev
1	22729	Mitchells*	7,010
2	24226	Clinchco	2,060
3	24348	Independence*	2,000
4	24620	Hurley	1,930
5	23801	Fort Lee	1,700
6	23106	Manquin	1,530
7	24614	Grundy	1,500
8	24597	Vernon Hill	1,470
9	24528	Brookneal	1,310
10	24248	Ewing	1,300

Only includes zips with pop  $\geq 1000$  and no supp. data.

\* Denotes zip codes with state prisons.

Point Prevalence by Zip Code  
(2022-02-26)

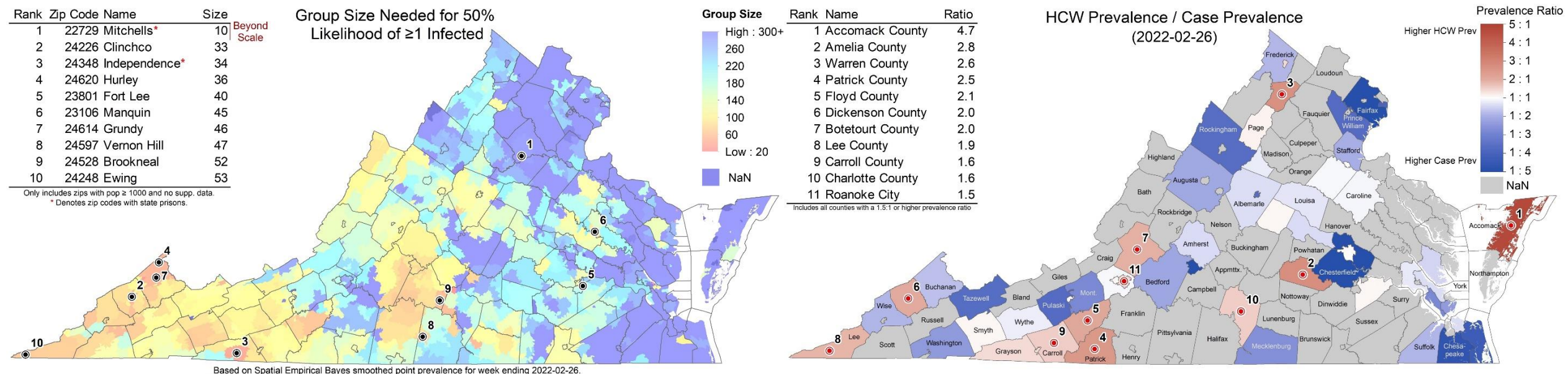


Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-02-26.

# Risk of Exposure by Group Size and HCW prevalence

**Case Prevalence in the last week by zip code used to calculate risk of encountering someone infected in a gathering of randomly selected people (group size 25)**

- **Group Size:** Assumes 2 undetected infections per confirmed case (ascertainment rate from recent seroprevalence survey), and shows minimum size of a group with a 50% chance an individual is infected by zip code (eg in a group of 10 in Mitchells, there is a 50% chance someone will be infected)
- **HCW ratio:** Case rate among health care workers (HCW) in the last week using patient facing health care workers as the denominator / general population's case prevalence



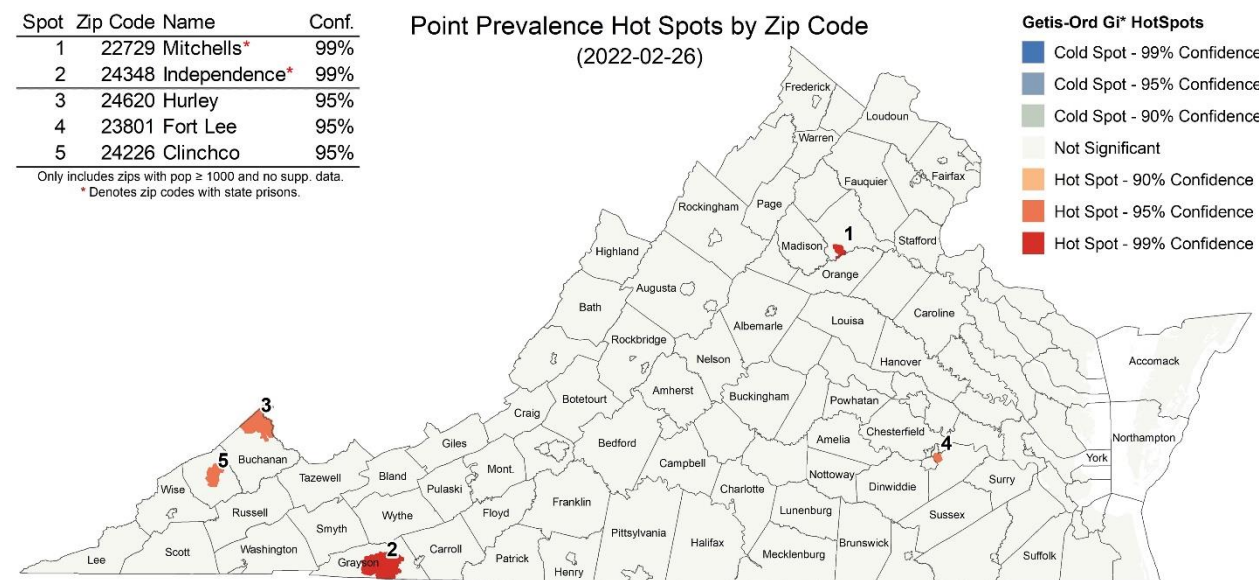


# Current Hot-Spots

## Case rates that are significantly different from neighboring areas or model projections

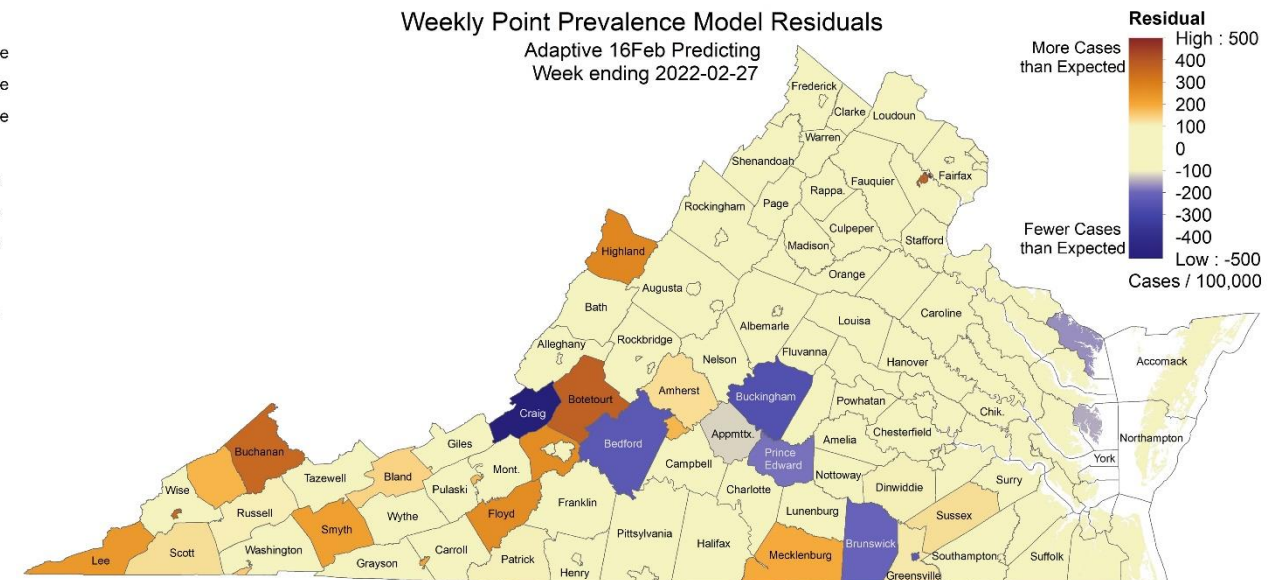
- **Spatial:** Getis-Ord Gi\* based hot spots compare clusters of zip codes with weekly case prevalence higher than nearby zip codes to identify larger areas with statistically significant deviations
- **Temporal:** The weekly case rate (per 100K) projected last week compared to observed by county, which highlights temporal fluctuations that differ from the model's projections

### Spatial Hotspots



Based on Global Empirical Bayes smoothed point prevalence for week ending 2022-02-26.

### Clustered Temporal Hotspots

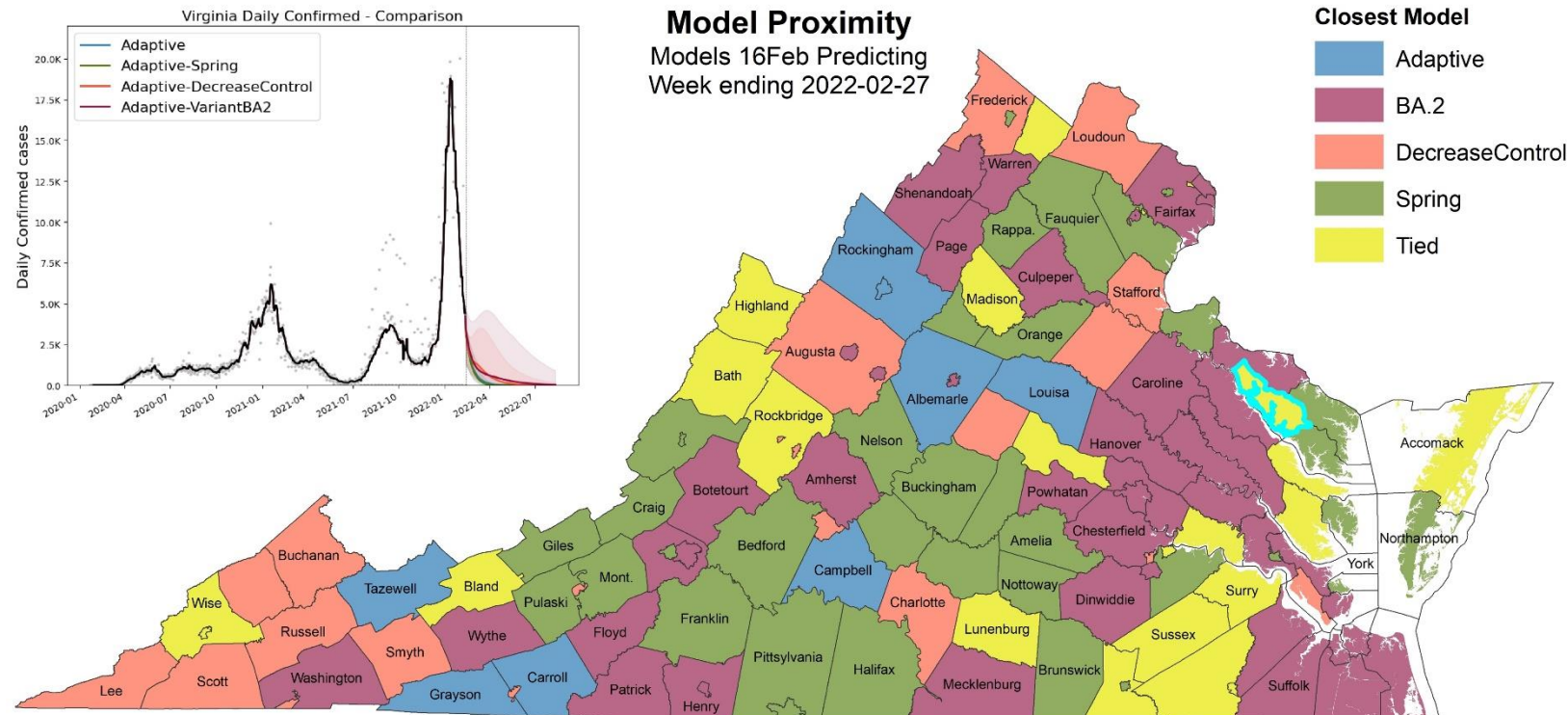
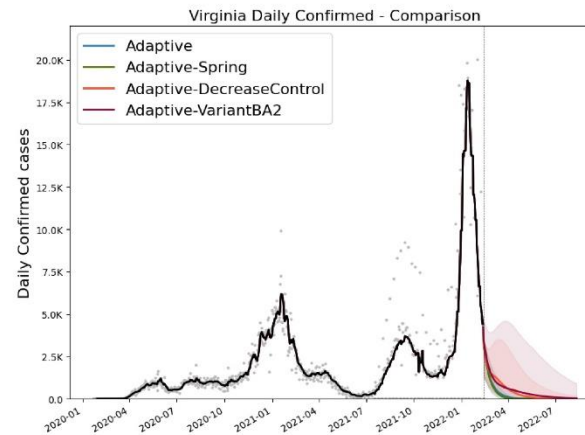


Moran's I = 0.019528, Z-Score = 1.742378, P-Value = 0.081442  
No Residual Autocorrelation Detected

# Scenario Trajectory Tracking

## Which scenario from last projection did each county track closest?

- Majority of counties tracked Adaptive-Spring closest (though is very similar to Adaptive)
- Handful of counties tracked the DecreasedControl and BA2 (mostly areas with hotspots of activity)





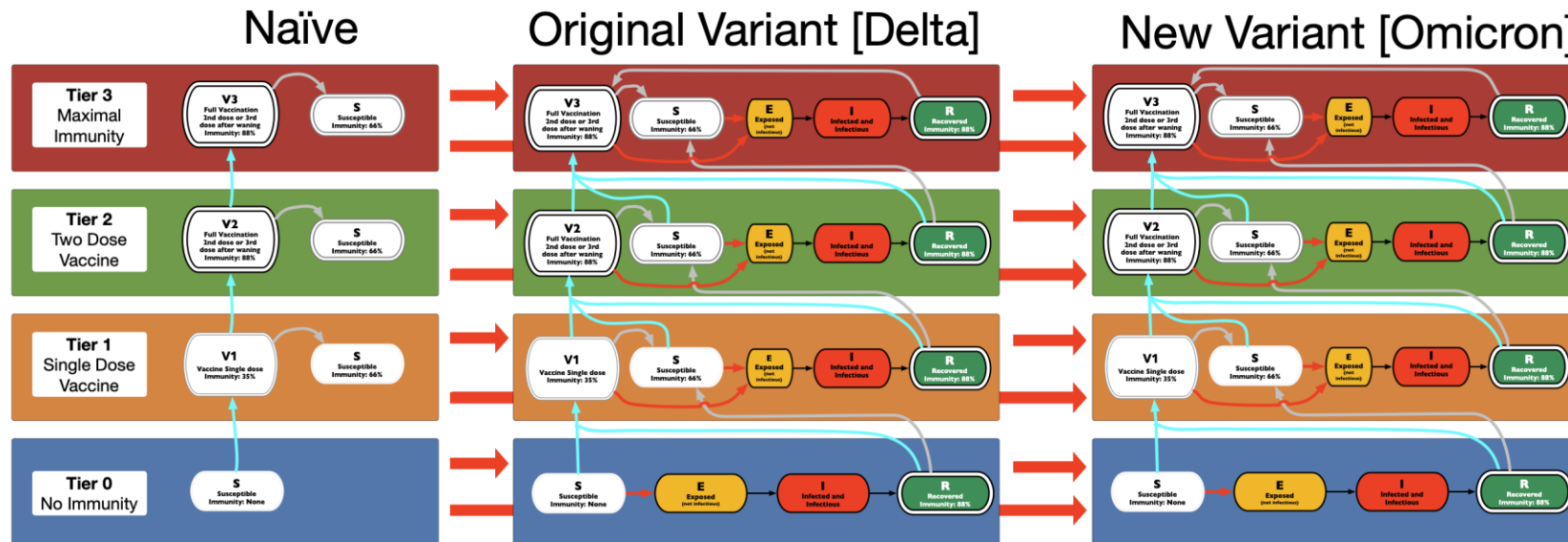
# Model Update – Adaptive Fitting

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# Model Structure Extended for Multiple Strains

## Omicron escapes immunity from vaccinated and those infected with Delta

- Multiple strain support allows representation of differential protection based on immunological history
- Severity of Outcomes varies by strain and level of immunity, thus allowing model to better capture hospitalizations and deaths from Omicron
- Adaptive fitting approach continues to use simulation to generate the full distribution of immune states across the population



# Adaptive Fitting Approach

## Each county fit precisely, with recent trends used for future projection

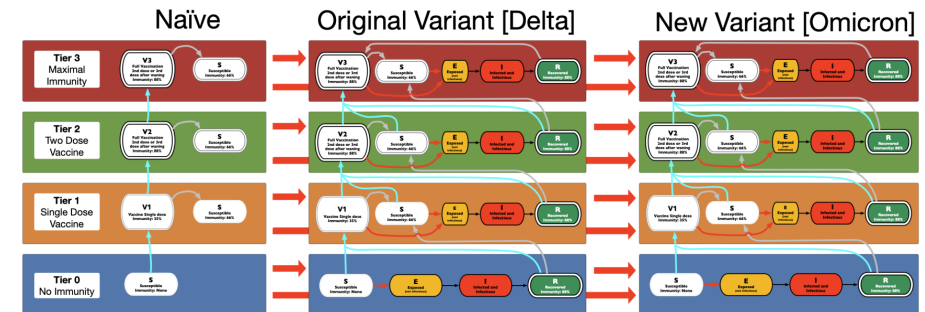
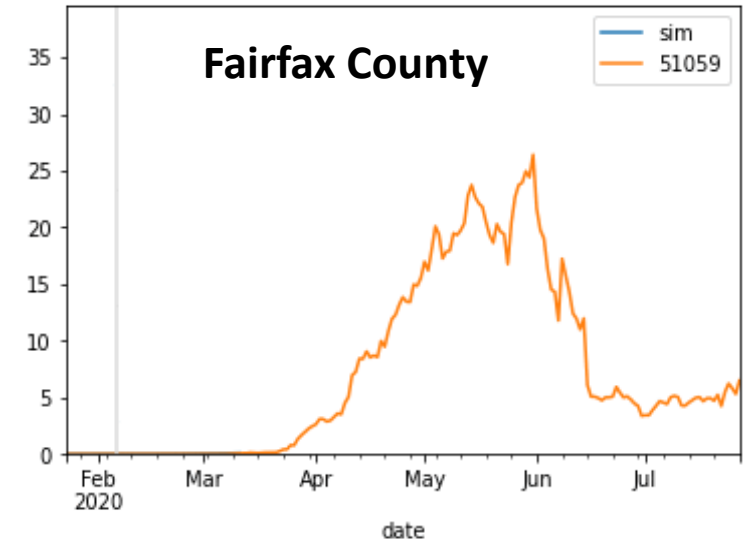
- Allows history to be precisely captured, and used to guide bounds on projections

## Model: An alternative use of the same meta-population model, PatchSim with multiple tiers of immunity

- Allows for future “what-if” Scenarios to be layered on top of calibrated model
- Allows for waning of immunity and for partial immunity against different outcomes (eg lower protection for infection than death)

## External Seeding: Steady low-level importation

- Widespread pandemic eliminates sensitivity to initial conditions, we use steady 1 case per 10M population per day external seeding



# Using Ensemble Model to Guide Projections

Ensemble methodology that combines the Adaptive with machine learning and statistical models such as:

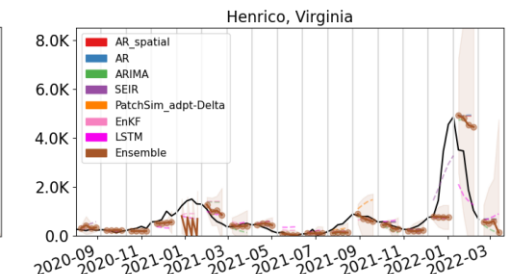
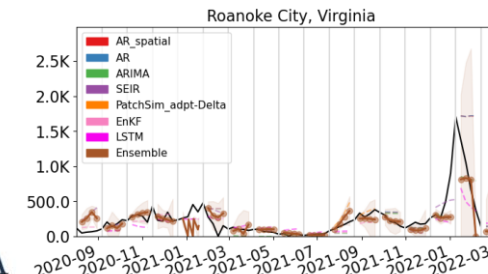
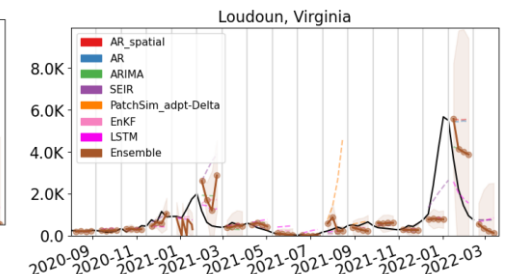
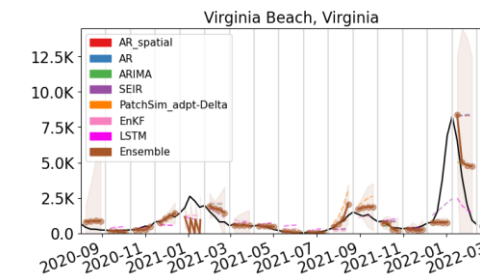
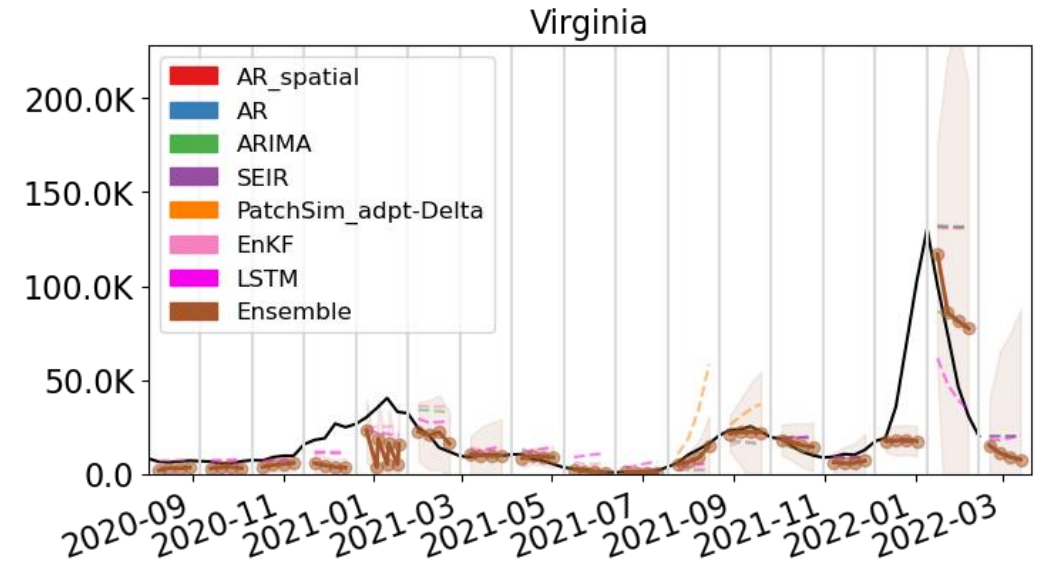
- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

Weekly forecasts done at county level.

Models chosen because of their track record in disease forecasting and to increase diversity and robustness.

Ensemble forecast provides additional 'surveillance' for making scenario-based projections.

Also submitted to CDC Forecast Hub.



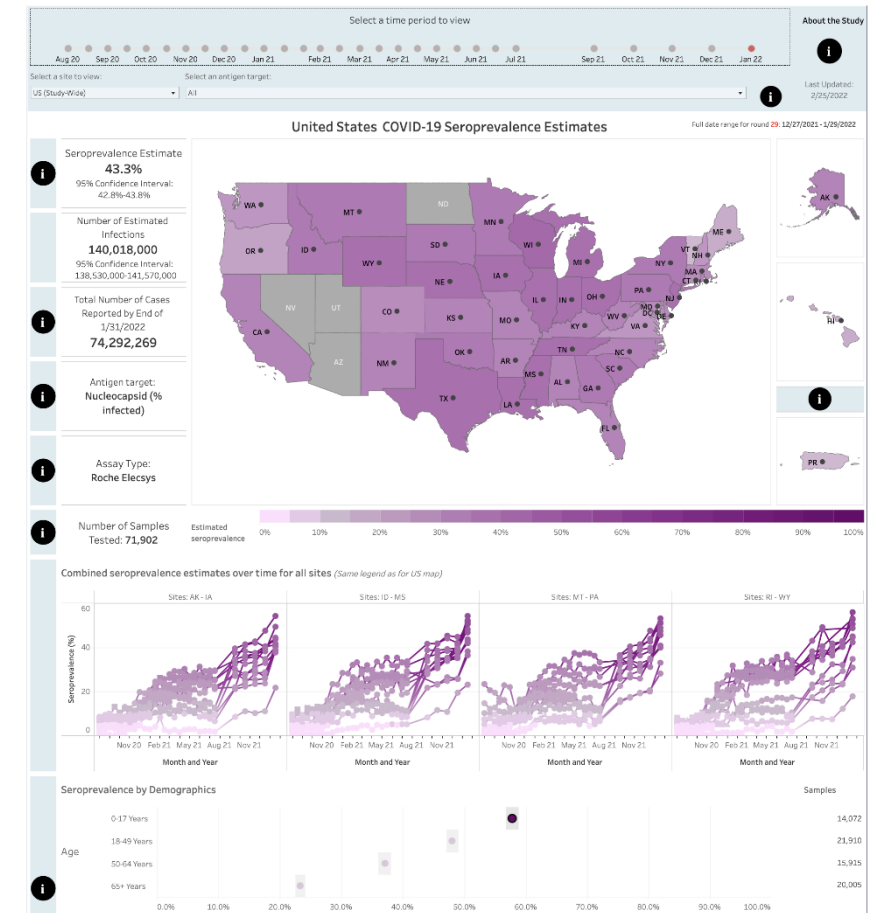
# Seroprevalence updates to model design

**Several seroprevalence studies provide better picture of how many actual infections have occurred**

- CDC Nationwide Commercial Laboratory Seroprevalence Survey

**These findings are equivalent to an ascertainment ratio of ~2x in the future, with bounds of (1.3x to 3x)**

- Thus for 2x there are 2 total infections in the population for every confirmed case recently
- **Case ascertainment is half of that for those with prior immunity**
- Uncertainty design has been shifted to these bounds (previously higher ascertainments as was consistent earlier in the pandemic were being used)



<https://covid.cdc.gov/covid-data-tracker/#national-lab>

# Calibration Approach

- **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting
- **Calibration:** fit model to observed data and ensemble's forecast
  - Tune transmissibility across ranges of:
    - Duration of incubation (5-9 days), infectiousness (3-7 days)
    - Undocumented case rate (1x to 7x) guided by seroprevalence studies
    - Detection delay: exposure to confirmation (4-12 days)
  - Approach captures uncertainty, but allows model to precisely track the full trajectory of the outbreak
- **Project:** future cases and outcomes generated using the collection of fit models run into the future
  - **Mean trend from last 7 days of observed cases and first week of ensemble's forecast used**
  - Outliers removed based on variances in the previous 3 weeks
  - 2 week interpolation to smooth transitions in rapidly changing trajectories
- **Outcomes:** Data driven by shift and ratio that has least error in last month of observations
  - Hospitalizations: 3 days from confirmation, 6.8% of cases hospitalized
  - Deaths: 11 days from confirmation, 1.45% of cases die

## COVID-19 in Virginia: Summary

Dashboard Updated: 3/1/2022  
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths					
Total Cases*		Total Hospitalizations**		Total Deaths	
1,641,438		47,284		18,811	
(New Cases: 1,496)^					
Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
1,170,683	470,755	44,505	2,779	15,579	3,232

\* Includes both people with a positive test (Confirmed), and symptomatic with a known exposure to COVID-19 (Probable).  
\*\* Hospitalization of a case is captured at the time VDH performs case investigation. This underrepresents the total number of hospitalizations in Virginia.

<sup>^</sup>New cases represent the number of confirmed and probable cases reported to VDH in the past 24 hours.

† VDH adopted the updated CDC COVID-19 confirmed and probable surveillance case definitions on August 27, 2020. Found here: <https://www.cdc.gov/nndss/conditions/coronavirus-disease-2019-covid-19/case-definition/2020/08/05/>

Source: Cases - Virginia Electronic Disease Surveillance System (VEDSS) data entered by 5:00 PM the prior day

Outbreaks	
Total Outbreaks*	Outbreak Associated Cases
<b>7,102</b>	<b>117,328</b>

\* At least two (2) lab confirmed cases are required to classify an outbreak.

Testing (PCR Only)	
Testing Encounters PCR Only*	Current 7-Day Positivity Rate PCR Only**
<b>12,805,949</b>	<b>8.4%</b>

\* PCR\* refers to "Reverse transcriptase polymerase chain reaction laboratory testing."

\*\* Lab reports may not have been received yet. Percent positivity is not calculated for days with incomplete data.

Multisystem Inflammatory Syndrome in Children	
Total Cases*	Total Deaths
<b>149</b>	<b>1</b>

\*Cases defined by CDC HAN case definition: <https://emergency.cdc.gov/han/2020/han00432.asp>

Accessed 9:30am March 2, 2022

<https://www.vdh.virginia.gov/coronavirus/>

# Scenarios – Transmission Conditions

- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- **Waning Immunity:** Mean of 6 months to a year protection (rate of 0.0027) similar to [Pfizer study](#)
- **Projection Scenarios:**
  - **Adaptive:** Control remains as is currently experienced into the future with assumption that Omicron remains as the majority strain, and that infection with Omicron provides protection against Omicron infection in the future
  - **Adaptive-Spring:** Same as Adaptive, except transmission rates are driven down by behaviors and seasonal effects by 60% over the next 2 months (as observed last Fall-Winter wave)
  - **Adaptive-DecreasedControl:** Same as Adaptive, except transmission rates are driven up by 60% in the coming 2 weeks
  - **Adaptive-VariantBA2:** Same as Adaptive, but with gradual emergence of BA.2 subvariant with a 2x transmission advantage over existing Omicron subvariants

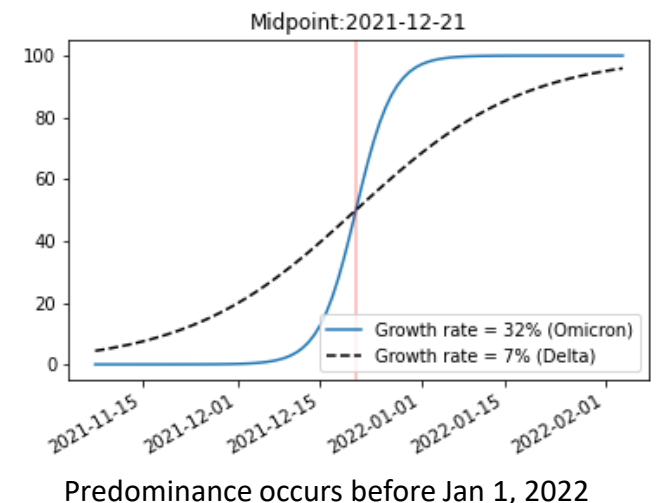


# Scenarios – Omicron Description

## Omicron shown ability to evade immunity and may be more transmissible

- **Transmissibility:** [New evidence suggests](#) that Omicron has **similar transmissibility** to Delta
- **Immune Evasion:** Strong evidence demonstrates that Omicron can cause infection in those with some immunity (natural and vaccine induced). Consensus estimate of **80% immune evasion** allows Omicron to infect 80% of individuals that would have otherwise been protected against Delta. Assume that recovery from Omicron provides protection to infection with Omicron similar pre-Omicron variants
- **Prevalence:** Proportion of cases caused by Omicron variant estimated from growth rates observed in other countries with similar levels of immunity (growth of 32%, doubling in ~3 days)
- **Severity:** Several reports suggest Omicron may not cause as severe disease as Delta, we use a 50% reduction in severity for hospitalizations and deaths
- **Studies:** [South Africa](#), [UK](#), [Canada](#)

**Estimated Prevalence curve for US**



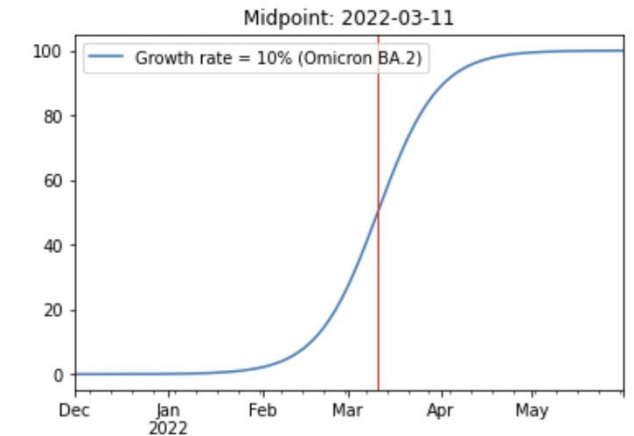


# Scenarios – Omicron BA.2 Description

## BA.2 shows signs of increased transmissibility

- **Transmissibility:** Analysis of household contacts in [Denmark](#) and the [UK](#) suggests a 40% to 3x increase in transmission. We assume a 2x boost for this scenario
- **Prevalence:** Detection in US has been widespread but limited; given growth observed elsewhere and US, and current estimated prevalence, this would lead to BA.2 prevalence of 50% in early March
- **Severity:** Assumed to be same as for other Omicron subvariants

## Estimated BA2 prevalence projection



This projected prevalence is based on the increase experienced in Denmark the growth rate in VA may be markedly different

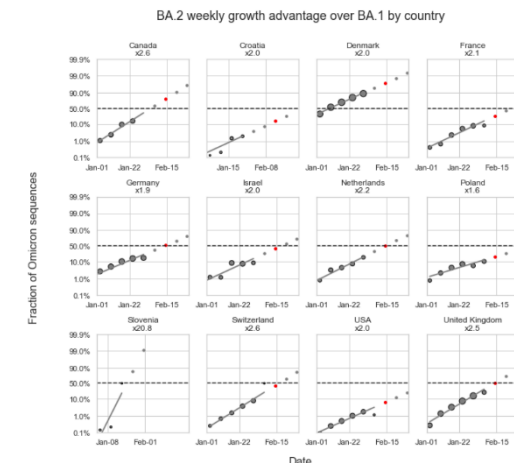
Table 3: Relative effect of Omicron VOC BA.2 vs. BA.1

	Susceptibility			Transmissibility		
	Unvaccinated	Fully vaccinated	Booster vaccinated	Unvaccinated	Fully vaccinated	Booster vaccinated
Omicron BA.2 households	2.19 (1.58-3.04)	2.45 (1.77-3.40)	2.99 (2.11-4.24)	2.62 (1.96-3.52)	0.60 (0.42-0.85)	0.62 (0.42-0.91)
Omicron BA.1 households	ref (-)	ref (-)	ref (-)	ref (-)	ref (-)	ref (-)
Number of observations	17,945	17,945	17,945	17,945	17,945	17,945
Number of households	8,541	8,541	8,541	8,541	8,541	8,541

Notes: This table shows odds ratio estimates for the effect of living in a household infected with BA.2 relative to BA.1. Column 1 and 4 shows the relative transmission of BA.2, conditional on being unvaccinated. Column 2 and 5 shows the relative transmission of BA.2, conditional on being fully vaccinated. Column 3 and 6 shows the relative transmission of BA.2, conditional on being booster vaccinated. Note, all estimates are from the same model, but with a different reference category across column 1-6. The estimates are adjusted for age and sex of the primary case, age and sex of the potential secondary case, size of the household, and primary case sample date. The estimates are furthermore adjusted for vaccination status of the potential secondary case and primary case interacted with the household subvariant. 95% confidence intervals are shown in parentheses. Standard errors are clustered on the household level. The odds ratio estimates for the full model are presented in Appendix Table 12, column 1

Variant	Household contacts becoming cases / all household contacts	Secondary attack rate amongst household contacts (95% CI)
VUI-22JAN-01 (BA.2)	64 / 476	13.4% (10.7%-16.8%)
Omicron excluding VUI-22JAN-01	10,444 / 101,773	10.3% (10.1%-10.4%)

UK Household Study  
[PHE Report](#)



Many countries  
Tracking a 2x  
Advantage for  
BA.2 vs. BA.1

Barak Raveh  
via [Twitter](#)

Danish Household Study - [MedArxiv](#)

# Projection Scenarios – Combined Conditions

Name	Txm Controls	Vax	Description
Adaptive	C	SQ	Likely trajectory based on conditions remaining similar to the current experience, includes immune escape due to Omicron
Adaptive-Spring	Spring	SQ	Assumes rapid decrease observed last Fall-Winter wave plays out till spring, resulting an overall decrease in transmission drivers of 60%
Adaptive-DecreaseControl	Decrease	SQ	Transmission rates in the next couple weeks are increased 60% and remain at that level demonstrate that increases in case rates remain possible despite the historically high rates, remaining vigilant has benefits
Adaptive-VariantBA2	C	SQ	Transmission rates for BA.2 infections are doubled. BA.2 prevalence rises over the course of next 8 weeks from not detected to ~95%

## Transmission Controls:

C = Current levels persist into the future

Decrease = Transmission rates are boosted by 60% over next couple weeks and remain at that level

Spring = Transmission rates from mid-Jan 2021 through mid-March 2021 are coarsely replayed, representing a 60% reduction in transmission rate drivers, with Omicron remaining dominant

## Vaccinations:

SQ = Status quo acceptance leads to low rates of vaccination through the summer

VO = Vaccination acceptance optimistically expands with increased rates through the summer

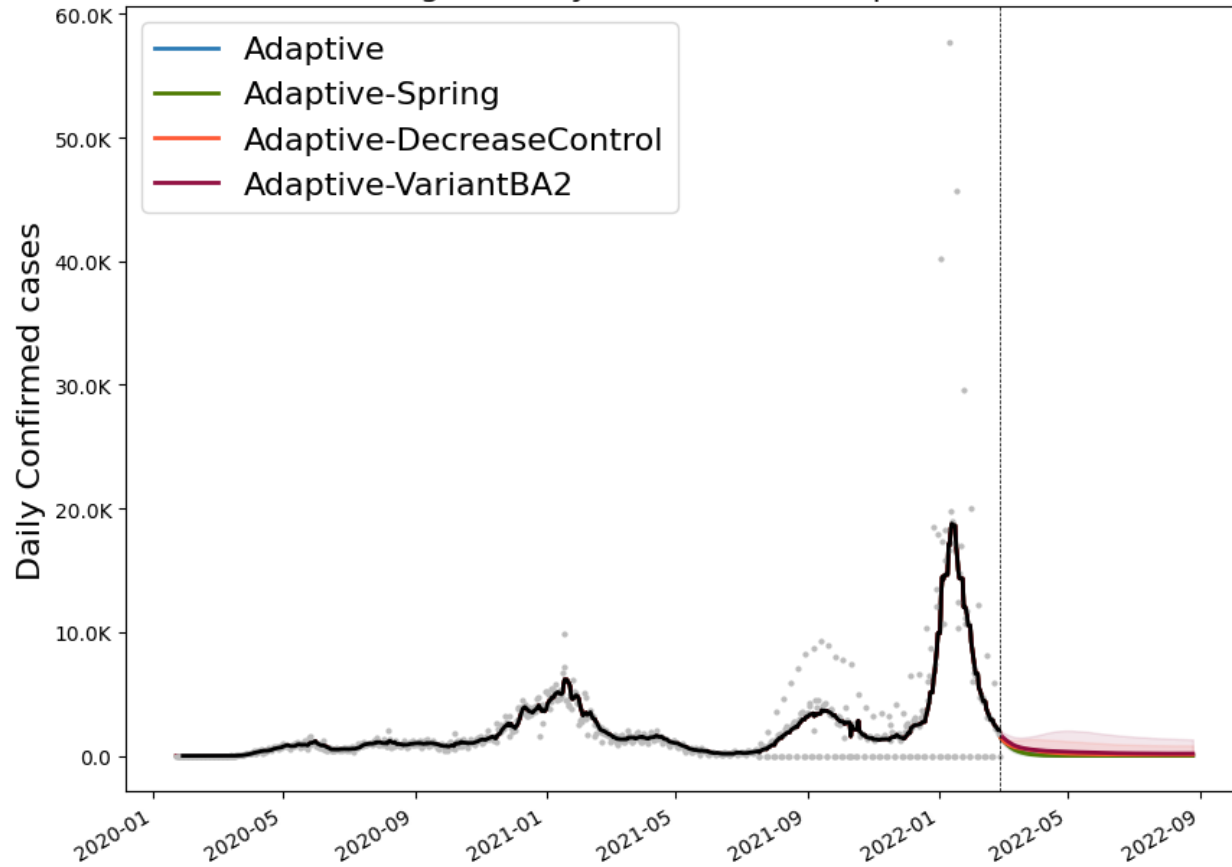
# Model Results

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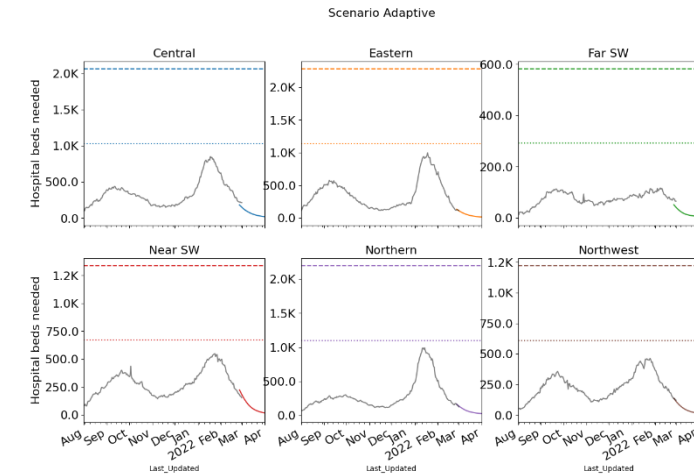
# Outcome Projections

## Confirmed cases

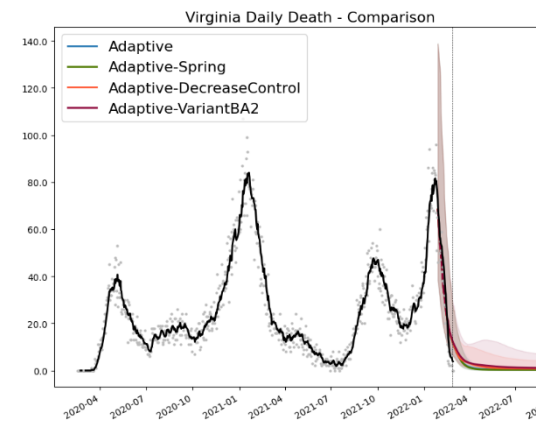
Virginia Daily Confirmed - Comparison



## Estimated Hospital Occupancy

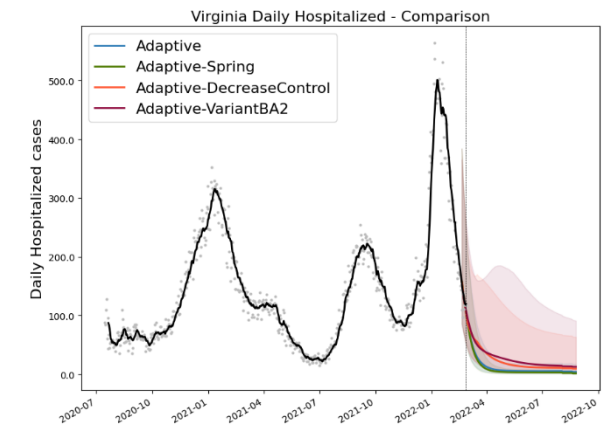


## Daily Deaths



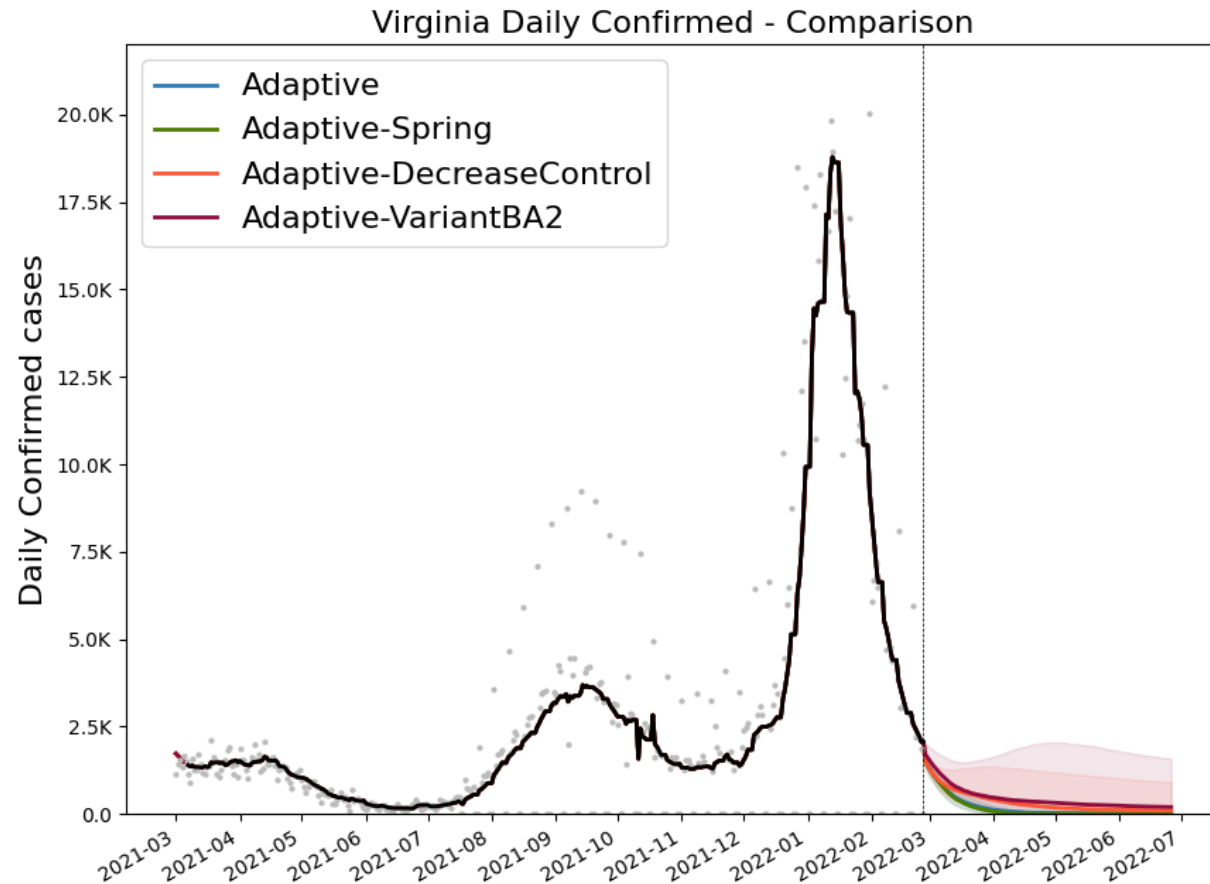
Death ground truth from VDH "Event Date" data, most recent dates are not complete

## Daily Hospitalized

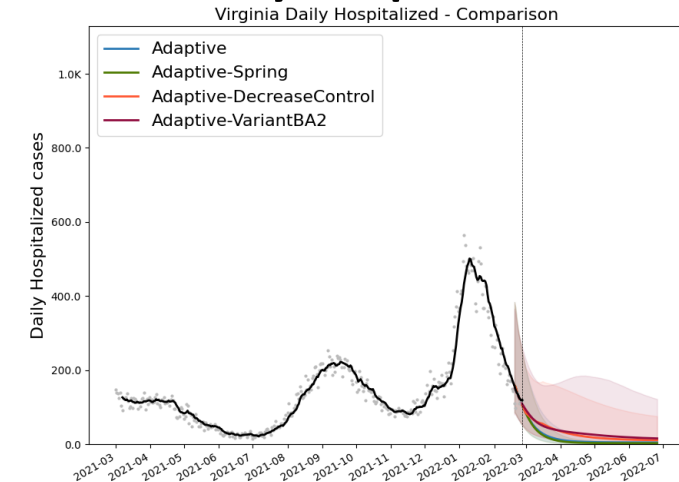


# Outcome Projections – Closer Look

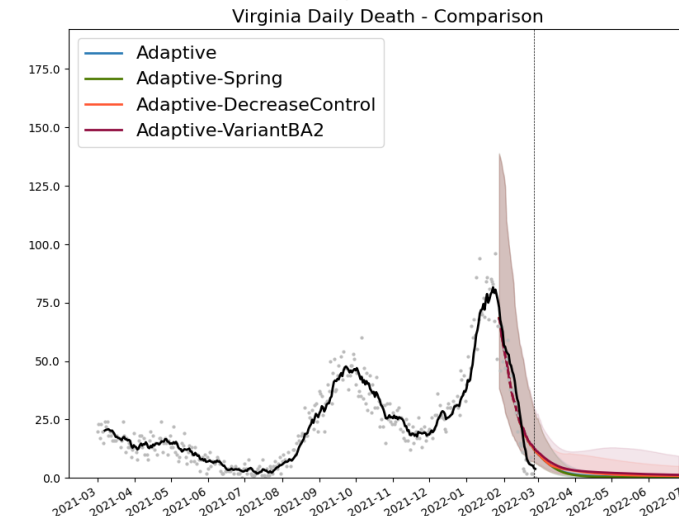
## Confirmed cases



## Daily Hospitalized



## Daily Deaths

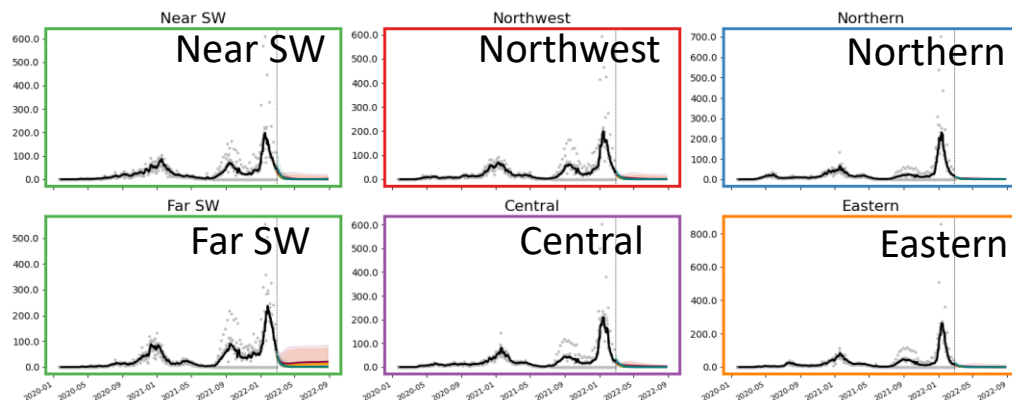


Death ground truth from VDH "Event Date"  
data, most recent dates are not complete

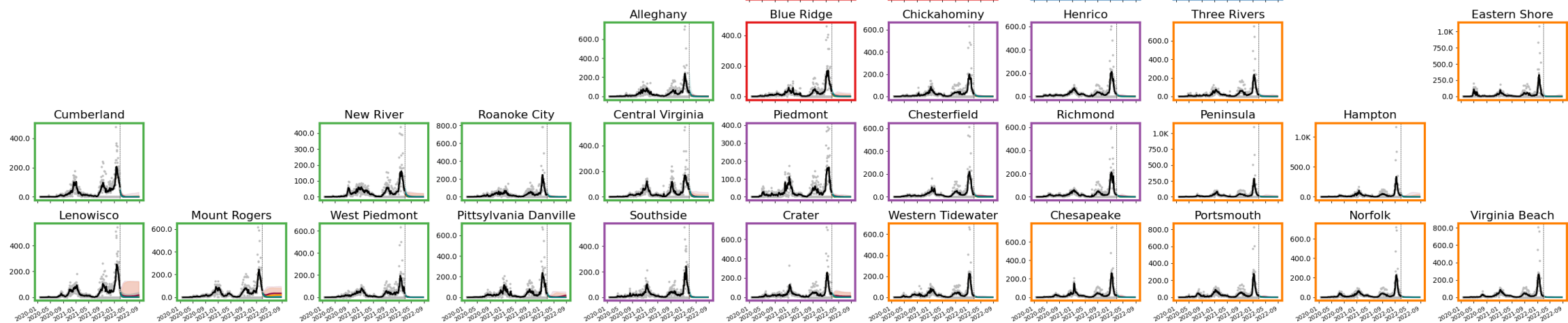


# Detailed Projections: All Scenarios

## Projections by Region



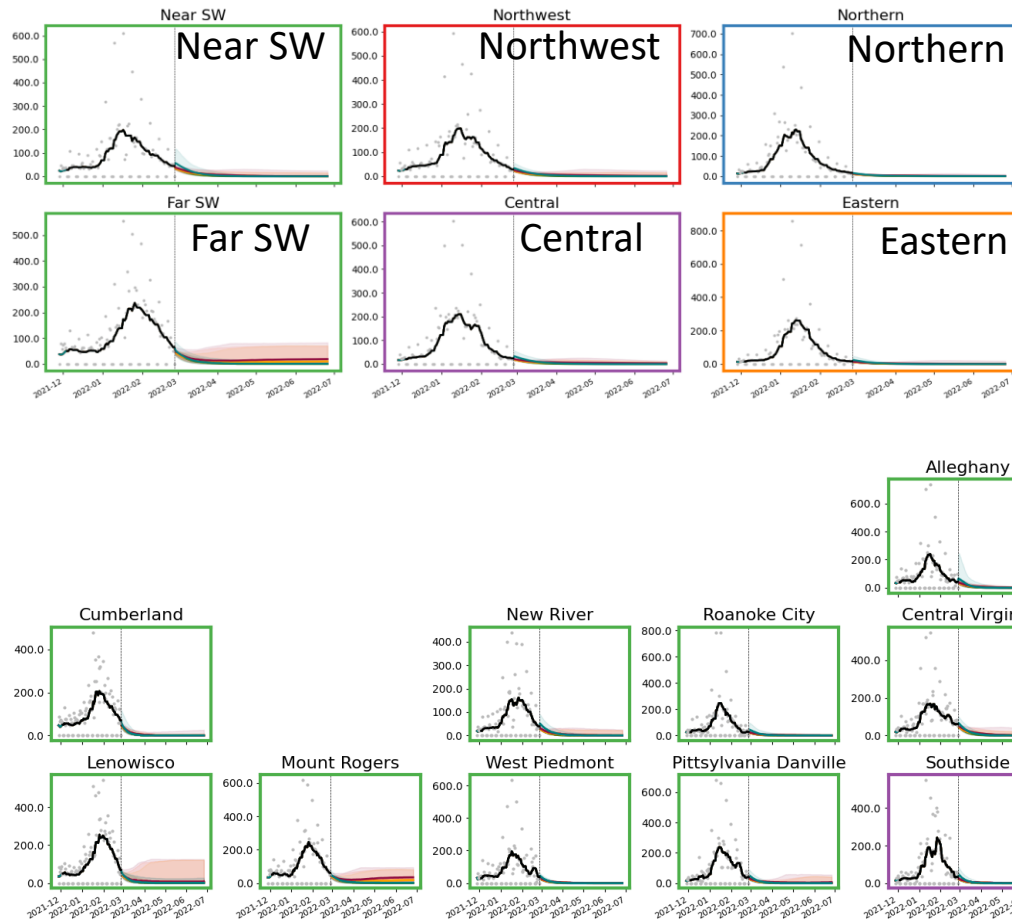
## Projections by District



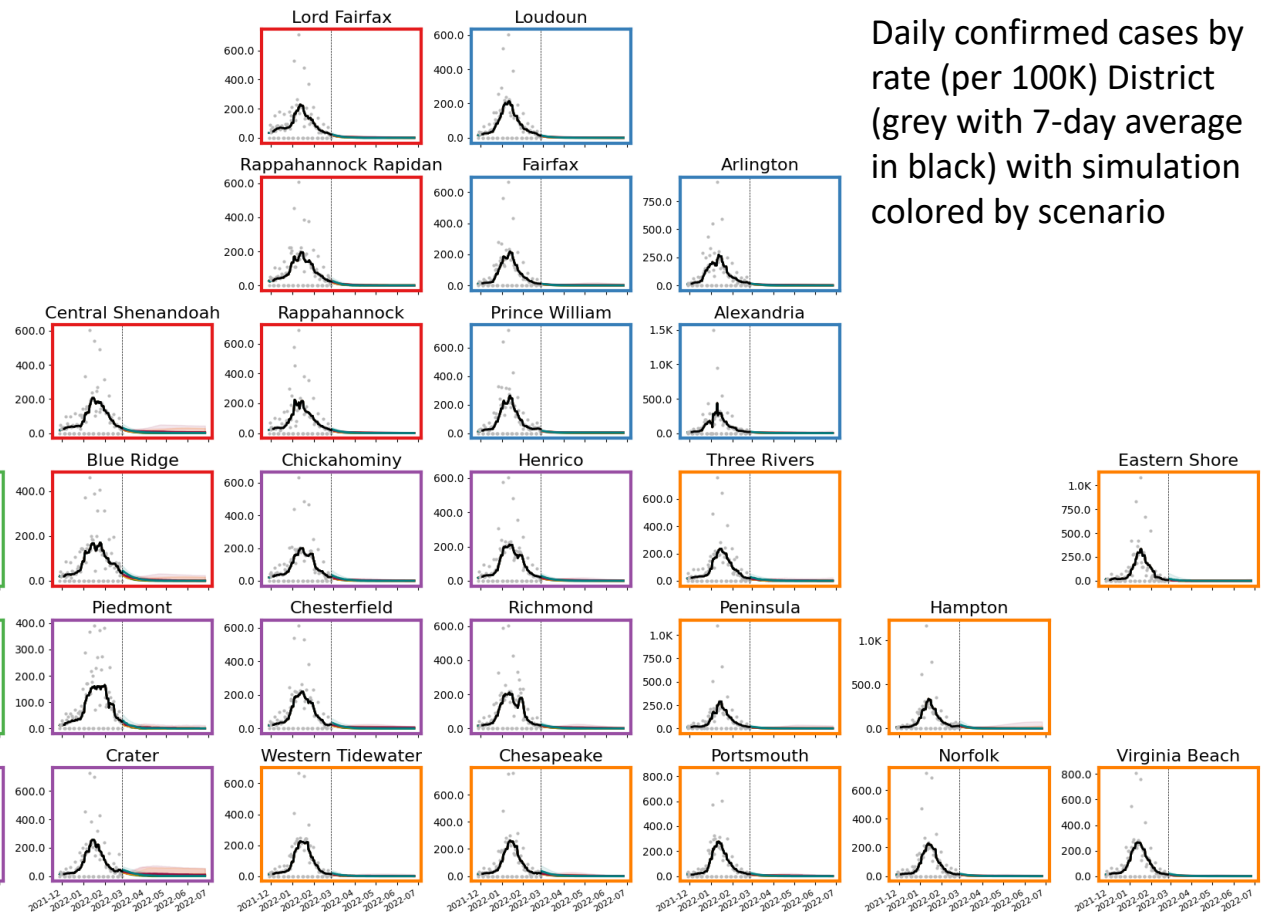
Daily confirmed cases)  
by rate (per 100K)  
District (grey with 7-day  
average in black) with  
simulation colored by  
scenario

# Detailed Projections: All Scenarios - Closer Look

## Projections by Region



## Projections by District



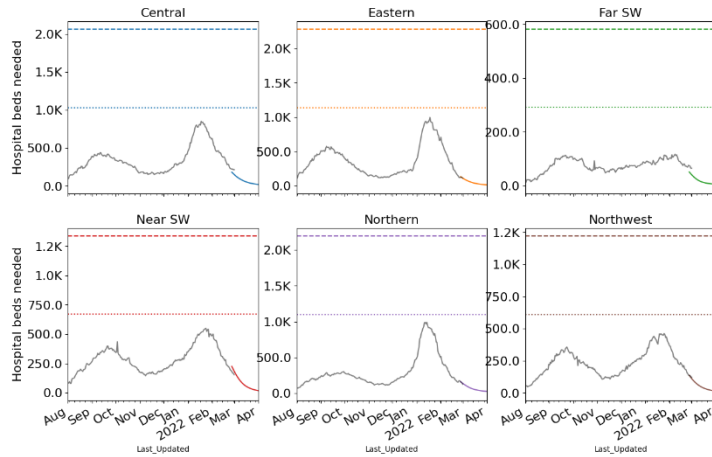
Daily confirmed cases by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

# Hospital Demand and Bed Capacity by Region

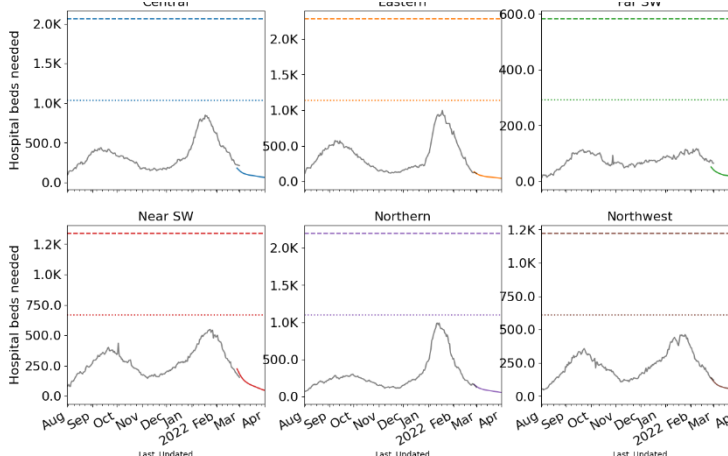
## Capacities by Region

COVID-19 capacity ranges from 80% (dots) to 120% (dash) of total beds

### Adaptive



### Adaptive – Decrease Control



**Length of Stay more variable with Omicron, occupancy projections may vary as a result, ad-hoc estimation performed per region**

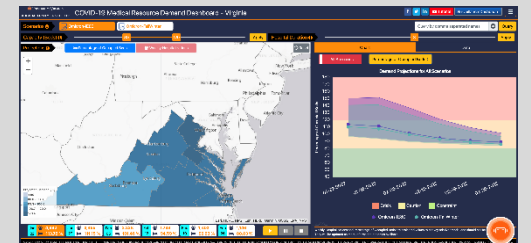
**Estimated LOS stable compared to last week**

**Projections show continued declines and with expanded capacities, and adjusted length of stay, no capacities exceeded**

### Length of Stay Estimates

Central	8
Eastern	7
Far SW	4
Near SW	8
Northern	6
Northwestern	8

Interactive Dashboard  
with regional  
projections

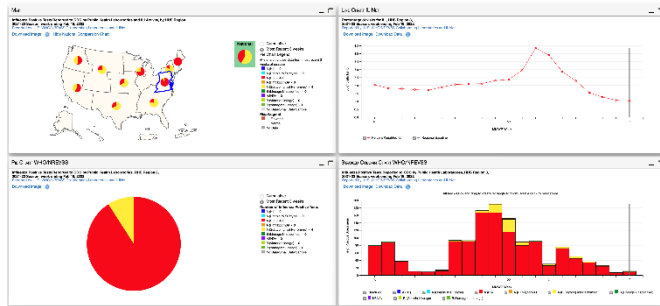


<https://nssac.bii.virginia.edu/covid-19/vmrddash/>

# Current Influenza Hospitalization Forecast

## Statistical models for submitting to CDC FluSight forecasting challenge

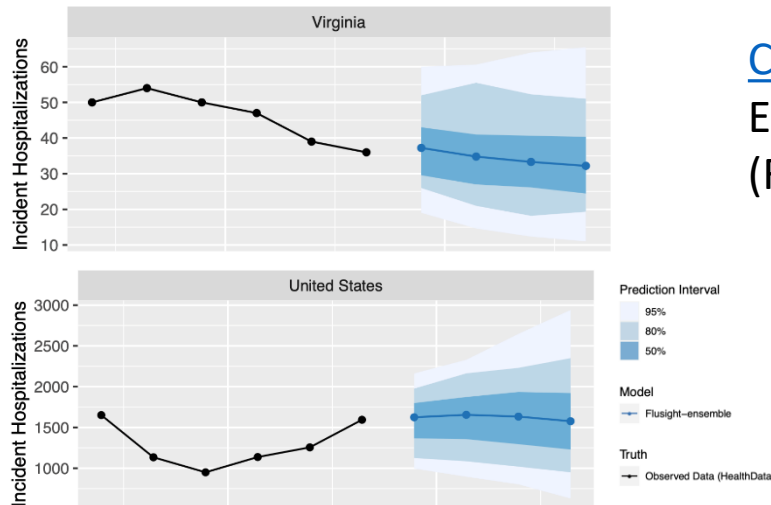
- Similar to COVID-19 case forecasts, uses a variety of statistical and ML approaches to forecast weekly hospital admissions for the next 4 weeks for all states in the US



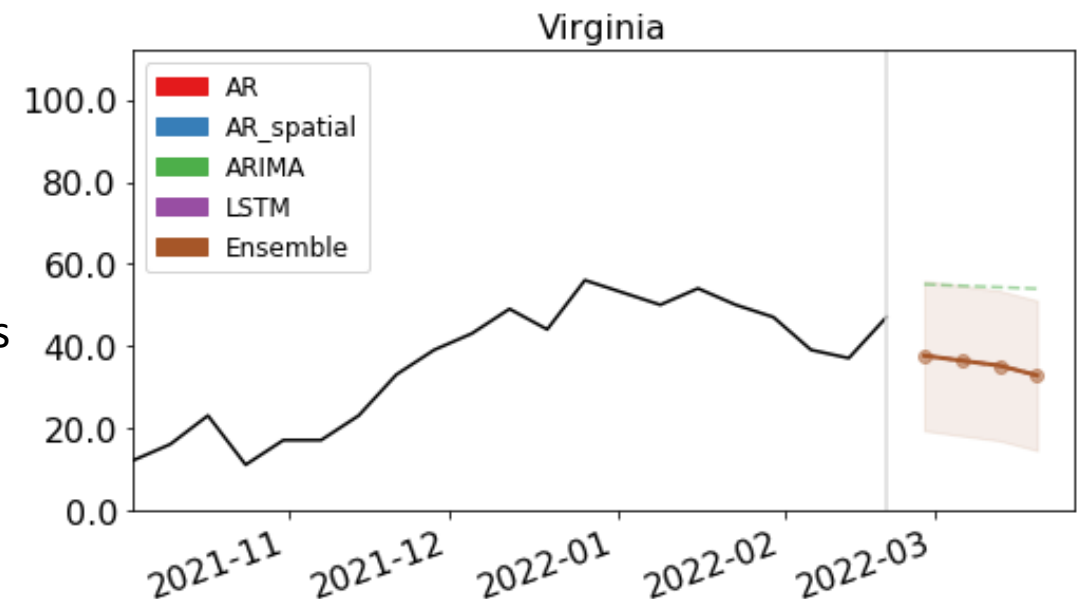
Influenza A activity dropping in our region  
Labs show high levels of H3 this season  
(Influenza A H3N2 is more severe)

[CDC FluSight](#)

Ensemble Forecasts  
(Feb 21)



## Hospital Admissions for Influenza and Forecast for next 4 weeks (UVA ensemble)



# Key Takeaways

Projecting future cases precisely is impossible and unnecessary.

Even without perfect projections, we can confidently draw conclusions:

- **Case rates and hospitalizations continue to decline**
- VA 7-day mean daily case rate is sharply down to 19/100K from 30/100K
  - US is also lower now down to 22/100K (from 26/100K)
- Projections anticipate continued declines:
  - BA2 subvariant of Omicron continues to grow, but much more slowly than in European countries
  - Rapidity decline and final level of decline depends on degree of protection to Omicron garnered by previous Omicron infection

The situation continues to change. Models continue to be updated regularly.





# Additional Analyses

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# Overview of relevant on-going studies

Other projects coordinated with CDC and VDH:

- **Scenario Modeling Hub:** Consortium of academic teams coordinated via MIDAS / CDC to that provides regular national projections based on timely scenarios
- **Genomic Surveillance:** Analyses of genomic sequencing data, VA surveillance data, and collaboration with VA DCLS to identify sample sizes needed to detect and track outbreaks driven by introduction of new variants etc.
- **Mobility Data driven Mobile Vaccine Clinic Site Selection:** Collaboration with VDH state and local, Stanford, and SafeGraph to leverage anonymized cell data to help identify

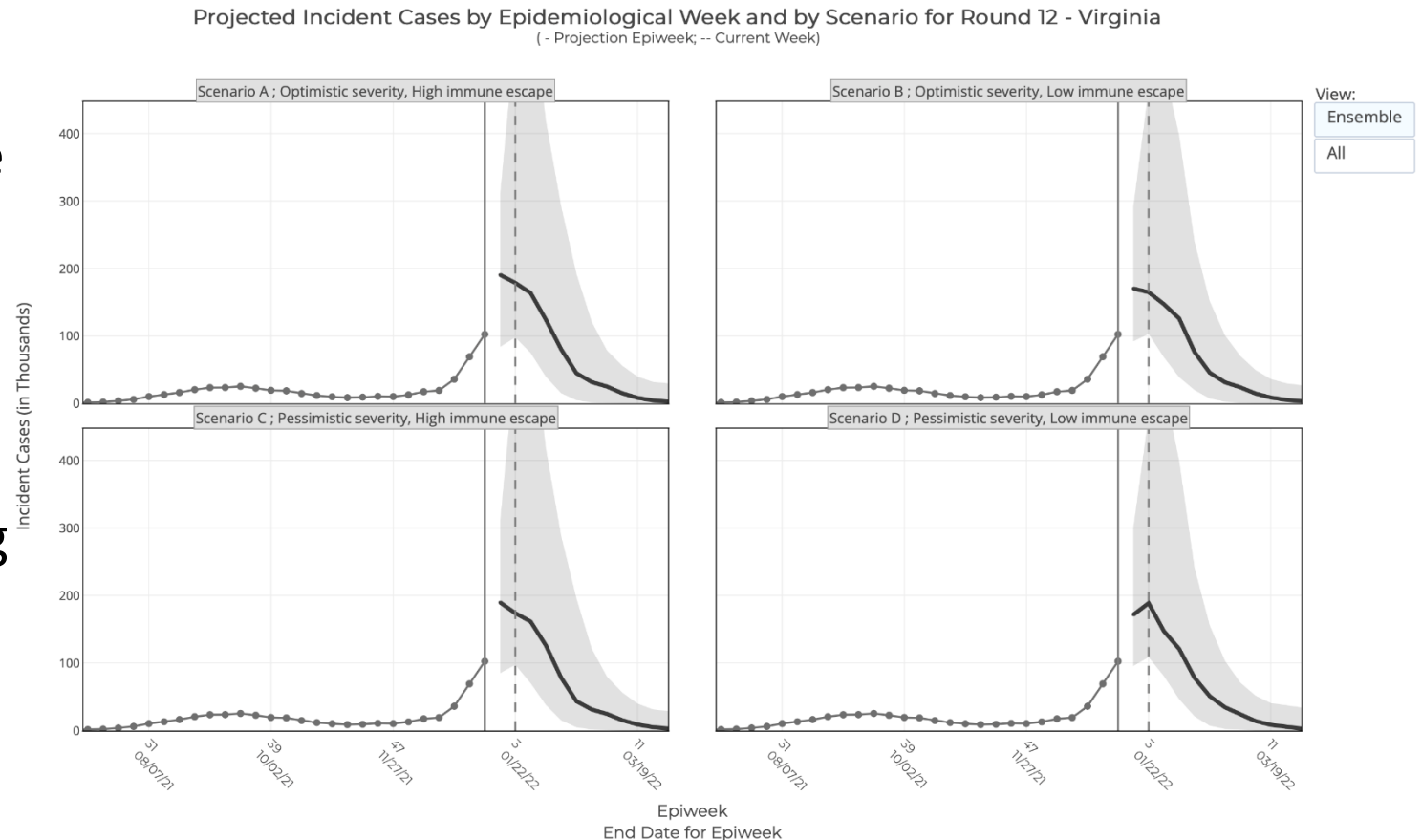
# COVID-19 Scenario Modeling Hub

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios that vary vaccine rates (high – low) and impact of the Delta variant (high and low)

- Round 12 recently released to assist in federal response to Omicron wave
- Only national consortium tracking Omicron wave well
- Rounds 4-11 now available

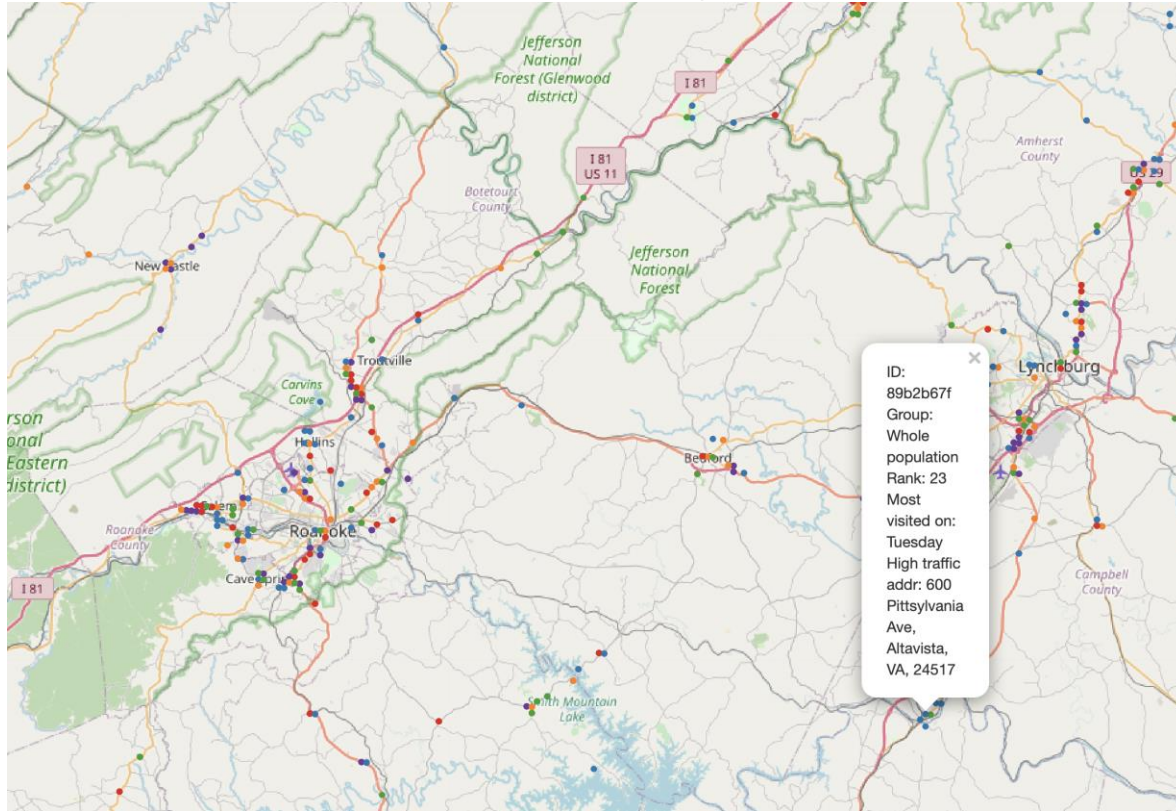
*Round 4 Results were published May 5<sup>th</sup>, 2021 in [MMWR](#)*

<https://covid19scenariomodelinghub.org/viz.html>



# Data Recommended Mobile Vax Clinic Sites

## Detailed and Timely Locations



## Data Delivered and Disseminated to Locals

Provides a list of areas most visited by a given demographic group based on SafeGraph mobility data that links visits to specific sites and the home Census Block Group of the anonymized visitors

**Demographic Groups:** Black, Lantinx, Young Adults (20-40), Unvaccinated, and Whole Population

**Data Included:** Rank, Weight, most visited Day of Week, Highly Visited Address, and Lat-Long of area

**Goal:** Provide frequently visited locations based on populations and vaccination levels one desires to reach

**Example:** List of location in the Southside frequented by 20-40 year olds





# References

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Adiga, Aniruddha, Srinivasan Venkatramanan, Akhil Peddireddy, et al. "Evaluating the impact of international airline suspensions on COVID-19 direct importation risk." *medRxiv* (2020)

NSSAC. PatchSim: Code for simulating the metapopulation SEIR model. <https://github.com/NSSAC/PatchSim>

Virginia Department of Health. COVID-19 in Virginia. <http://www.vdh.virginia.gov/coronavirus/>

Biocomplexity Institute. COVID-19 Surveillance Dashboard. <https://nssac.bii.virginia.edu/covid-19/dashboard/>

Google. COVID-19 community mobility reports. <https://www.google.com/covid19/mobility/>

Biocomplexity page for data and other resources related to COVID-19: <https://covid19.biocomplexity.virginia.edu/>

# Questions?

## Points of Contact

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## Biocomplexity COVID-19 Response Team

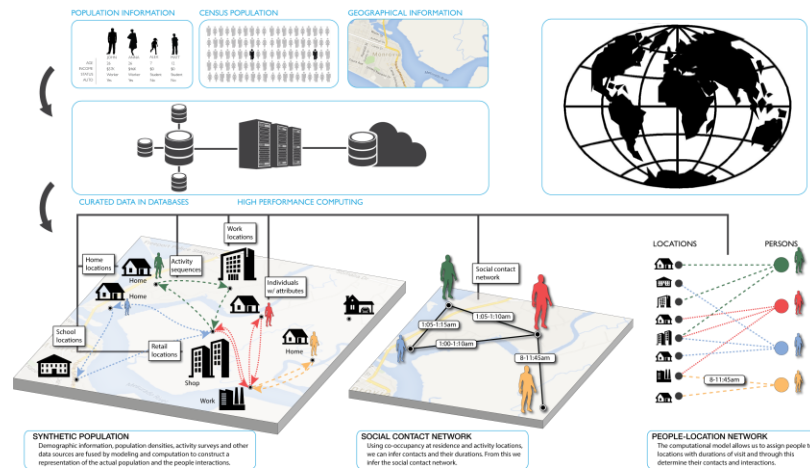
Aniruddha Adiga, Abhijin Adiga, Hannah Baek, Chris Barrett, Golda Barrow, Richard Beckman, Parantapa Bhattacharya, Jiangzhuo Chen, Clark Cucinell, Patrick Corbett, Allan Dickerman, Stephen Eubank, Stefan Hoops, Ben Hurt, Ron Kenyon, Brian Klahn, Bryan Lewis, Dustin Machi, Chunhong Mao, Achla Marathe, Madhav Marathe, Henning Mortveit, Mark Orr, Joseph Outten, Akhil Peddireddy, Przemyslaw Porebski, Erin Raymond, Jose Bayoan Santiago Calderon, James Schlitt, Samarth Swarup, Alex Telionis, Srinivasan Venkatramanan, Anil Vullikanti, James Walke, Andrew Warren, Amanda Wilson, Dawen Xie

# Supplemental Slides

# Agent-based Model (ABM )

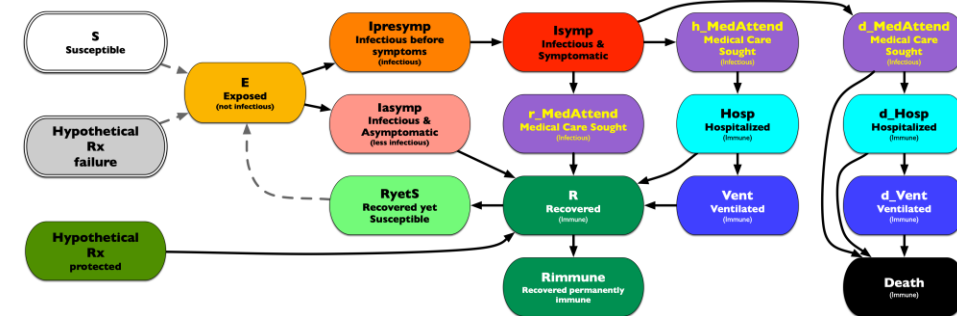
## EpiHiper: Distributed network-based stochastic disease transmission simulations

- Assess the impact on transmission under different conditions
- Assess the impacts of contact tracing



### Synthetic Population

- Census derived age and household structure
- Time-Use survey driven activities at appropriate locations



### Detailed Disease Course of COVID-19

- Literature based probabilities of outcomes with appropriate delays
- Varying levels of infectiousness
- Hypothetical treatments for future developments